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ASSESSMENT OF FACTORS AFFECTING BUILDING MAINTENANCE MANAGEMENT AUDITING IN SAUDI ARABIA

BY

Abdul Aziz Mesaad Abdullah Al-Zahrani

A Thesis Presented to the

DEANSHIP OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

In

ARCHITECTURAL ENGINEERING

MAY, 2001

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This thesis, written by Abdul Aziz Mesaad Abdullah Al-Zahrani under the direction of his Thesis Advisor and approved by his Thesis Committee, has been presented to and accepted by the Deanship of Graduate Studies, in partial fulfillment of the requirement for the degree of MASTER OF SCIENCE IN ARCHITECTURAL ENGINEERING.

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This thesis is dedicated to my father, mother, wife and daughter.

ACKNOWLEDGEMENT

I am most grateful to ALLAH, the Almighty for providing me with the capability to finish this research work.

Acknowledgements are due to King Fahd University of Petroleum & Minerals (KFUPM) for offering all facilities and support.

I wish to express my sincere appreciation to Professor Abdul Mohsin A. Al-Hammad, the thesis committee chairman, for his guidance and support throughout this work. I am grateful to him for his continuous efforts he puts into his students, to guide them through. I also wish to thank committee members, Professor Salih O. Duffuaa and Dr. Mohammed S. Al-Homoud for their valuable suggestions, comments, assistance and support throughout the research and writing period.

I would like to thank the department chairman, Dr. Ismail M. Budaiwi, who was helpful and encouraging.

Finally, I express my gratitude to my parents, brothers, sisters for their continued encouragement. I am also grateful to my wife and daughter for their encouragement, support and patience. Thanks also to all my friends who had a role in making this work possible.

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THESIS ABSTRACT

Student Name	:	**Abdul Aziz Mesaad Al-Zahrani**
Study Title	:	**Assessment of Factors Affecting Building Maintenance Management Auditing in Saudi Arabia**
Degree Date	:	**May 2001**

This thesis presents current local and international practices of building maintenance management auditing, identifies factors affecting auditing, and identifies and ranks factors affecting auditing of maintenance departments in large organizations in Saudi Arabia. The objective of this thesis is to assess factors affecting maintenance management auditing and then develop a suitable auditing form for building maintenance. To achieve these objectives, previous studies and previously developed audit forms were reviewed, and a survey was designed to assess the opinions of specialists in the maintenance field towards various factors and their importance.

The developed questionnaire was distributed to large organizations in the Eastern province of Saudi Arabia. A total 100 questionnaires were distributed to governmental and private organizations, 50 for each. A total of 25 completed responses were received from governmental organizations and 22 were received from the private sector. The survey was statistically analyzed. The survey showed that 84% of the factors and sub-factors are ranked as "Important" while others are "Extremely Important" and "Moderately Important" by the total samples. In addition, these factors are categorized into six main components, namely: organization & human resources, work load identification & performance measures, work planning & scheduling, work accomplishment, information technology & appraisal, and material management. Each component is composed of many factors and sub-factors. These factors were ranked according to their importance indices. The result indicated that governmental and private organizations agree on ranking factors affecting building maintenance management auditing in Saudi Arabia.

Based on the literature review, the outcome from the questionnaires and the calculated importance index for each factor, a suitable auditing form for building maintenance management in Saudi Arabia was developed. The survey showed a lack of awareness on the subject of maintenance management and a need for auditing techniques, since there is no standard audit form or procedure to be followed by each organization's auditors.

Finally, conclusions and recommendations were presented.

MASTER OF SCIENCE DEGREE
KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS
Dhahran, Saudi Arabia
MAY, 2001

بسم الله ارحمن الرحيم

خلاصـــة الرسالـــــة

اســـم الطالب الكامل: عبد العزيز بن مساعد بن عبد الله الزهراني

عـــنـــوان الدراســـة: تقييم أداء إدارات صيانة المباني في المملكة العربية السعودية

الدرجـــــــــــــة: ماجستير العلوم

التخصـــــــــــــص: هندسة معمارية

تـــــاريخ الـــــتخرج: مايـــو 2001 م

تقـــدم هـــذه الرسالة موضوع تدقيق ومراجعة أداء إدارات صيانة المباني محلياً وعالمياً وتهدف إلى التعرف على العوامل المؤثـــرة في تقيـــيم أداء إدارات الصيانة في المنشآت الكبيرة في المملكة العربية السعودية وترتيب هذه العوامل حسب أهميـــتها وتطوير نموذج للمراجعة والتدقيق. ولتحقيق هذه الأهداف تم البحث في المرحلة الأولى من خلال الدوريات والدراســـات والـــنماذج المستخدمة لتقييم نظام إدارات الصيانة . وبعد ذلك تم استخدام استبانه صممت للبحث عـــن العناصر المؤثرة في التقييم وأهميتها وقد تم توزيع الاستبانات على 50 مؤسسة حكومية و 50 مؤسسة خاصة في المـــنطقة الشـــرقية مـــن المـــملكة العربية السعودية، وتم الحصول على 25 استبانه مكتملة من القطاع الحكومي وكذلـــك 22 اســـتبانه مكتمـــلة من القطاع الخاص. ومن خلال تحليل النتائج تبين أن معظم العناصر المؤثرة على إدارات الصـــيانة اتفق على أنها " مهمة " بينما بعضها " مهمة جداً " والبقية " مهمة نوعاً ما " . وقد تم تقسيم هـــذه العناصـــر إلى ست مجموعات رئيسية وكل مجموعة مكونة من عدد من العناصر والعناصر الفرعية وقد رتبت حســـب أهميـــتها . وقـــد أوضـــحت النتائج تطابق وجهات النظر في ترتيب أهمية العناصر بين القطاعين الحكومي والخاص في المملكة العربية السعودية .

وبـــناءً عـــلى نـــتائج الدراســـة فقـــد تم تطويـــر آليـــة لتصـــميم نمـــوذج لتقيـــيم أداء إدارات الصـــيانة في المملكة العربية السعودية كما تم تقديم العديد من التوصيات لتطوير وتحسين هذا الأنموذج.

درجة الماجستير في العلوم

جامعـــة المـــلك فهـــد للبتـــرول والمعـــادن

الظهران ، المملكة العربية السعودية

مايـــو 2001م

CHAPTER I

INTRODUCTION

1.1 BACKGROUND

Although the maintenance department constitutes a large share and plays an active role in every organizational framework, it has been neglected by most organizations (1). A lot of resources are spent on new projects but insufficient budgets are allocated to maintain them. Even during the recruitment phase in a maintenance department, not enough attention is given to employing technically qualified personnel, nor is any in-house training arranged for the employees to upgrade their skills and knowledge. Most organizations do not even have suitable offices and workshops to carry out their work in order to efficiently maintain and operate facilities (2).

In Saudi Arabia during the construction boom, new cities were planned, major industries were set up, a massive road network was laid, and many large construction projects were completed (2,3). But recently, there is an increased demand for maintaining this infrastructure in a good and acceptable condition, hence more attention is being given to maintenance policies. Nowadays in Saudi Arabia most of the Ministries and large companies have begun to feel the importance of maintenance and therefore more attention is being given to the establishment and functioning of operation and maintenance departments.

Currently, maintenance techniques and strategies are also being taught in universities in subjects such as maintenance management, productivity of maintenance laborers, engineering economics, and socio-technical management. Research projects and studies are also being conducted in this area to gather information on various aspects of maintenance in order to enhance current maintenance programs. As a part of these ongoing research projects, this field study has been conducted on maintenance auditing. It is aimed at helping organizations in Saudi Arabia to review, analyze and recommend ways of increasing the effectiveness of their maintenance departments.

1.2 STATEMENT OF THE PROBLEM

It is necessary for the maintenance management to know the state of their organization's maintenance: whether it is organized in the right way to achieve their objectives or whether some actions should be taken to improve their maintenance management approaches.

One major problem facing maintenance managers is that they don't know whether their organization system is improving or deteriorating. If managers are auditing the system, the need to know whether they include the important and right factors to be audited or not. In such cases if the auditing does not consider influencing factors, auditors will report incorrectly to the management and improper actions will be taken. Identifying factors affecting maintenance management auditing and rating the importance of these factors is very important to reach a suitable action plan to improve maintenance systems.

1.3 OBJECTIVES

The main objectives of this study are to:

(i). Review current local and international practices of building maintenance management auditing.

(ii). Identify and assess factors affecting building maintenance management auditing.

(iii). Identify and rank factors affecting auditing of maintenance departments in large organizations in Saudi Arabia.

(iv). Develop a suitable maintenance management auditing form for organizations in Saudi Arabia, considering local socio-cultural, economic and environmental issues.

1.4 SCOPE AND LIMITATIONS

In this study, factors affecting building maintenance management will be reviewed and assessed through a literature review, site visits and interviews with specialized personnel. The study will be limited to large facilities in the Eastern province of the Kingdom of Saudi Arabia. The survey will include maintenance departments in industrial, commercial and government buildings.

1.5 SIGNIFICANCE OF THE STUDY

Building projects in Saudi Arabia cost billions of Riyals. Keeping these facilities in a condition in which they perform their functions as designed for is very important. Maintenance management should be audited to ensure the effectiveness of the system, and managers should make any necessary improvements according to rational studies. There are many factors affecting the nature of auditing of building maintenance management in Saudi Arabia, such as social, environmental, the lack of regulations, and a lack of awareness of the importance of maintenance auditing. The importance of the study comes from the facts that:

1. There are no standard auditing techniques for maintenance organizations in Saudi Arabia,

2. There is a need for the assessment of factors affecting auditing in large facilities and the level of their importance,

3. There is a need to look into facilities owners' and expert maintenance contractors' perceptions of the importance of auditing of maintenance organizations,
4. There is a lack of awareness on this subject.

5. The development of a suitable maintenance management auditing form for organizations in Saudi Arabia is needed.

1.6 THESIS ORGANIZATION

This thesis discusses factors affecting auditing of building maintenance management in Saudi Arabia in order to review the practice of auditing by maintenance departments and develop an auditing form suitable for building maintenance management. The thesis is divided into six chapters and two appendices.

Chapter I is an introduction to auditing, which gives the reader an overall view and the main objectives of the study.

Chapter II presents previous studies which have been conducted in this field, discusses maintenance principles, audit types and phases.

Chapter III presents the factors affecting building maintenance management.

Chapter IV presents the research methodology and the survey details.

Chapter V presents findings of the questionnaire and the results.

Chapter VI is devoted to a summary, conclusions and recommendations.

CHAPTER II

LITERATURE REVIEW

2.0 INTRODUCTION

In order to evaluate the maintenance systems, recommend and carry out the improvement actions, the maintenance department's mission should be clear. Before conducting the audit, a plan should be established detailing who will perform the audit, which factors will be considered, and what are the auditing phases. In this chapter, previous studies in maintenance management principles and auditing are highlighted.

2.1 PREVIOUS STUDIES

Maintenance management has been given broad attention by many authors. There are many studies which have been conducted on many aspects of maintenance management. The following are examples of studied subjects related to maintenance management:

a) Organization of maintenance management
b) Paper work and documentation of maintenance jobs.
c) Scheduling and planning of maintenance jobs.
d) Maintenance work measurement standards.
e) Preventive maintenance and facilities inspections.
f) Maintenance performance appraisals.
g) Material control.

h) Maintenance budgets.

i) Computerized maintenance management.

Although many studies have been conducted in the field of maintenance management, there is a noticeable lack of research on auditing of building maintenance management.

Auditing of maintenance management helps authorities determine if they are going the right way to meet their objectives and set goals. Although it is not easy for maintenance management to improve systems and productivity, it is necessary to keep attempting to do so through the utilization of their resources in the most effective manner as part of their responsibility in maintenance management. A well-planned and conducted audit lead to the improvement of the maintenance program's effectiveness, increase the quality of performance, and assist meeting productivity and desired goals. This can be enhanced by using management information systems and better utilization of resources. Applied Management Engineering (which is a recognized engineering firm) and Harvey H. Kaiser (4) introduced maintenance management audit in 1991. The review activity and appraisal should lead to improving operations and maintenance systematically. The basic phases of maintenance management auditing can be summarized as follows:

1. Establishment of priorities and scheduling the audit;
2. Organization of the audit;
3. Formation of the audit team;
4. Audit performance;

5. Report preparation;
6. Management action based on the received report;
7. Follow-up of audit results.

Improving maintenance quality using statistical process control tools has been studied by Salih O. Duffuaa and Mohammad Ben-Daya (5). They concentrated in their study on seven quality tools in maintenance management and the needed data. They found some questions to be answered, such as: what are the most critical factors?

Answering such questions and solving problems that cause poor quality maintenance can lead to a better class maintenance.

Duffuaa and Raouf (6) conducted a study on continuous maintenance productivity improvement using a structured audit. They proposed a structured audit approach to improve maintenance systems. Also it is noted that there is a need for a productive maintenance system, as indicated by many other researchers. The structured form considers scoring of the factors according to their importance or weight.

Price Waterhouse Cooper (7) developed a questionnaire to evaluate maintenance programs. The questionnaire included many statements on each factor, each statement given a score ranging from 0 to 4. The main factors included were: maintenance strategy, organization and human resources, employee empowerment, maintenance tactics, reliability analysis, performance measures/bench marking, information technology, planning and scheduling, materials management and maintenance process re-engineering.

DeGroote (8) proposed a maintenance performance evaluation approach based on a quality audit and performance indicators of maintenance. The quality audit should be conducted in four stages, as follows:

1) Survey of the influencing parameters;
2) Analysis of collected data, conclusions and recommendations;
3) Improvement action plan;
4) Justification of the proposed improvement plan based on cost-benefit.

Five major factors were indicated in the conclusions and recommendations of the study, as follows:

i) Production equipment;
ii) Organization and management of maintenance;
iii) Material resources;
iv) Human resources;
v) Work environment.

Audit of maintenance performance needs both well-experienced and structured methodology. The audit leads to more fundamental re-engineering of organizational structure, changing of personnel behavior, quality, cost, safety and environment. DeGroote (8) concluded that more improvement dimensions will be added to the framework as more assessment of maintenance performance is conducted.

The importance of information technology for maintenance management has been studied by many researchers. Computerized systems can help

maintenance management in many aspects. Planning, scheduling and coordination of maintenance works require a lot of interactions with different sections in which information technology can be utilized.

The following can be covered:

- Long-term, medium-term and short-term planning;
- Resource management for maintenance;
- Evaluating maintenance performance.

Developments in information technology enabled management to change organization, working methods and performance to be more efficient (9)

Al-Sultan (10) studied maintenance issues in the Kingdom of Saudi Arabia, such as needs, planning and budgeting. These factors affect directly the audit of maintenance management. Also maintenance management practices were reviewed. The study indicated that effective maintenance management is needed in the Kingdom of Saudi Arabia, andnd many recommendations related to the subject of auditing were made, such as:

- Formation of a national maintenance program.
- Introducing a course in maintenance management to all engineers and business schools.
- Development of maintenance training courses and workshops.
- Introduction of maintenance audit programs and bench marking.
- Encouraging writing books in Arabic on maintenance management.
- Arrangements of symposia and conferences on maintenance management.

2.2 ASSESSMENT OF MAINTENANCE MANAGEMENT PRINCIPLES

Maintenance management should have clearly defined objectives and descriptions of duties to facilitate the management in assessing its effectiveness and evaluating their performance. If good planning of auditing is executed, it will result in good ideas for improvement (9). Effectiveness in maintenance management is indicated by the following factors:

I. Productivity

Productivity is an indication of productive time directly spent by workers. Optimum productive time is usually about 65% (1). Auditing is used to improve a productive maintenance system which must be productive to achieve its objectives (6).

II. Performance

Performance can be defined as the actual hours compared to planned hours required to execute the work. It is difficult to measure the performance of maintenance due to different situations, parameters and lack of a performance standard (1,4,12).

The following factors should be considered in measuring maintenance performance, as classified by Campbell in 1995 (11):

1. Equipment Performance
2. Cost of Performance
3. Measure of Process Performance.

Assessment of maintenance performance is a very important parameter of maintenance management to increase the effectiveness of a maintenance organizations (8).

III. Work Quality

Production of new materials of various types used by maintenance laborers, affects the quality of work (5). There are a lot of books and articles talking about work quality control, but there is no standard or unique checklist of methods to assess the quality of maintenance work, and there is no definition that can be followed to know whether any work is done well or not (1,5,4,13). Quality evaluation is a subjective measure. Also the quality of work can be indicated by the assessment of following factors (1,12):

1. Waiting time
2. The standard of service provided
3. Staff satisfaction
4. Number of complaints
5. Facility suitability

IV. Priority

Priority assures that the most important jobs are done first. Maintenance works are classified into the following categories (1,11):

1. First Priority: Given for emergencies, in which delay will affect safety and health.

2. Second Priority: Given for jobs of less priority than emergency but where delay might cause bad results. This type of work is usually conducted within a week of issuing the work request.

3. Third Priority: Given for normal jobs which can be scheduled and planned after requests are issued by users.

2.3 DEFINITIONS OF AUDITING

- Audit, as defined by The American Heritage Dictionary, is "an examination of records or accounts to check their accuracy".

- "Auditing is a process in which one person verifies the assertions of an other", as defined by C. William Thomas and Emerson O. Henke (14).

- Another definition, given by Carmichael, Willingham and Schaller, is: "Auditing is an independent investigation of some particular activity" (15).

- Harvey H. Kaiser and Applied Management Engineering explained that the purpose of maintenance management auditing is to assure that management is meeting its goals and objectives (4).

2.4 TYPES OF AUDITS AND AUDITORS

2.4.1 TYPES OF AUDITS

- Earlier researches and articles concentrated on financial auditing. Theories and concepts of financial auditing were given more attention by scientists and organizations. After 1900, authors and experts started writing about other important types of audits such as: (4,14)

(i) Compliance Audits
(ii) Internal Audits
(iii) Operational Audits

These types of auditing share many components and procedures.

I. Compliance Audits

This type of audit is usually done by government agencies to ensure that activities meet the organizational objectives. It consists of financial and performance audits (14,16).

II. Internal Audits

Internal auditing is done by team from the same department. This team assesses and evaluates their system and reports to higher authorities in the same organization. The internal auditors might suggest a correction in the system, recommend changes, and put forward a plan to improve the audited organization (4,14,17,18).

III. Operational Audits

These are audits of comprehensive activities, such as management performance, internal systems, structural organization and work flow. This type of auditing is done by all types of auditors. It gives a report to recommend improvements in both effectiveness and efficiency of the audited organization (14). Operational auditing assesses the principal measurable services meeting both quality and user satisfaction in the following areas (1,4,17,18,19):

- Accuracy
- Appearance
- Behavior
- Documentation
- Performance
- Reliability
- Time

2.4.2 TYPES OF AUDITORS

Auditing might be conducted by one or more of the following types of auditors:

I. Independent Auditors

These are a team assigned to audit the organization. Independent auditors must be expert in their business and usually they are of highly knowledgeable and experienced (4,15).

II. Internal Auditors

Internal auditors are from the maintenance organization staff. They should be highly experienced. After assessment of the system, they report to senior management their findings and suggest improvements required.

III. Government Auditors

Government auditors are employees doing auditing for government agencies to assure that agencies and organizations are following regulations and laws efficiently (14,15,20).

Auditing is conducted by one or more of these types of auditors, but it is advised that some senior employees from audited department should be in the team (4).

2.5 AUDITING PHASES

Maintenance management audit is necessary to provide a proposed improvement to the system. It helps the management in the following ways (4,8,18,21,22):

- Insuring that maintenance is carrying out its mission and meeting its objectives.
- Increasing the quality of work
- Helping the management to establish a good organization structure.

- Automating and recommending information systems to increase effectiveness and productivity.

- Making a better control on resources.

- Highlighting problems and obstacles, and recommending how to avoid or minimize them.

To achieve these mentioned objectives, several phases must be followed to get a sound audit report. These phases are shown in Fig. 2.1 (4,14,18,19,22,23):

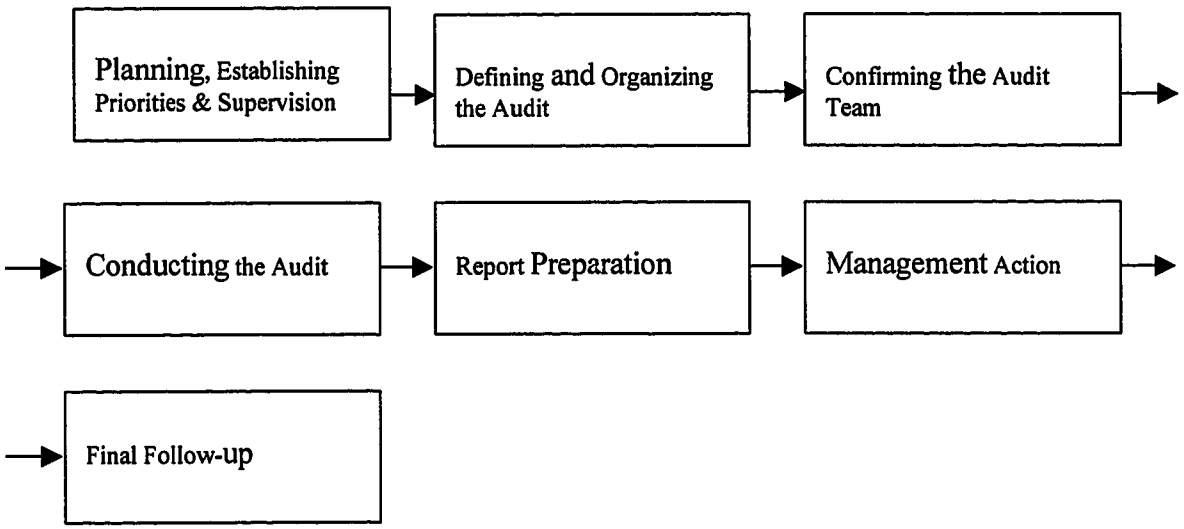

Fig. 2.1 : Auditing Phases (15)

I. Planning

Planning includes: establishing priorities and supervision before starting auditing, scheduling of nominated activities to be audited and assigining the chairman of the team. (4,18).

II. Defining and Organizing the Audit

This phase identifies items to be audited related to some scale, either quantity or quality; provides and confirms guidelines of the audit process; sends questionnaires to managers of departments and establishes scope and work plans (4,24).

III. Confirming the Audit Team

In this phase some members of the department might be added to the team. The membership of the team is confirmed, the scope of the audit, methods and procedures are outlined (4,15,24).

IV. Conducting the Audit

In this phase the following taskes are performed:

- Data collection by site visits to working areas, interviews with laborers and users, etc.

- Organizating and tabulating findings and problems.

V. Report Preparation

Reporting is a very important stage of auditing since it reflects what is going on to the higher level management and actions will be taken based on the report.

VI. Management Action

After the management receives the report, it might be discussed with the chairman of the team, and management will issue any decisions to improve

the system. It is important to get support from directors of departments to conduct improvement actions (4).

VII. Final Follow-up

Actions taken based on the recommendations should be monitored, implementation should be reported on periodically, and critique should be encouraged to review and evaluate the outcomes (4,24).

CHAPTER III

KEY COMPONENTS OF MAINTENANCE MANAGEMENT AUDITING

3.0 INTRODUCTION

As mentioned earlier, the maintenance organization's effectiveness is indicated by productivity, performance, work quality, and priority.

Researchers and auditors of some maintenance management departments develop questionnaires for auditing to help in the assessment of the important factors affecting maintenance auditing, such as:

- The questionnaire developed by Applied Management Engineering, PC, and Harvey H. Kaiser (4).

- The questionnaire developed by Price Waterhouse Cooper (7).

- The questionnaire used by an auditing team of King Fahd University Maintenance Department management (25).

- The questionnaire distributed in a seminar entitled "Assessment of Building Maintenance Management, Theory & Practice" in Dammam (13).

- The outline of corrective action factors initiated by Duffuaa and Raauf (6).

- Some important factors of maintenance management auditing in building maintenance management books and other references.

The management attempts to achieve their department's objective, so they are responsible for planning, organizing, leading and controlling their personnel (20).

Also, Maintenance Management's objective is to retain the building and system in as-built condition, to keep operation at a productive level and reduce energy consumption, so there are some important components composed of key elements to analyze and evaluate the maintenance management system (1,4,6,9,11,12,13). These components and elements are shown in Table 3.1. (pp. 61-66).

3.1 ORGANIZATION & HUMAN RESOURCES

Each department must have already defined lines of authority and responsibility in its organization. Each employee should have a specific area of authority and responsibility. An organization chart is issued to illustrate procedures and activities of the organization. The organization is evaluated to identify job descriptions and responsibilities. Maintenance staff should be experienced and capable in order to handle their jobs efficiently (4,7). The Organization & Human Resources component is composed of the following elements (4,7,25):

- Organization (structure)
- Policies, Rules & Services
- Work Control Center Functions & Staffing
- Shop Organization
- Shop Supervision & Planning Functions
- First Line Supervisors & Responsibilities
- Training

3.1.1 ORGANIZATION STRUCTURE

It is very important for small or large organizations to have organization structure to specify responsibilities, tasks and authorizations for each employee. Methods and measures should be very clear to define jobs in the organization structure (4,8,12,14). The organization structure might be composed of the following elements:

1. **Organization Chart**

This is a diagram showing the relationships of departments, divisions, sections and individuals in the organization (20).

2. **Function Statement**

A function statement documents authority, responsibilities and roles for each position (4).

3. **Job Description**

This is an outline description of essential position tasks and responsibilities. Each employee should be provided with a copy of his job description in order to understand his role (4,20).

4. **Updating Procedure**

Documentation of the organization chart, function statement, and job descriptions should be available, periodically reviewed and updated.

3.1.2 POLICIES, RULES AND SERVICES

Objectives, policy and rules of the maintenance organization should be stated and documented. Procedures also should be reviewed and updated regularly (4). This element can be made up of two components:

1. **General Policies**

Each organization should have clarified objectives, mission and general policies documented (1,4).

2. **Complete Services**

Relationships of Maintenance department sections, organizations and services should be defined and distributed clearly (4).

3.1.3 WORK CONTROL CENTER FUNCTIONS, STAFFING

The work control room is the heart of the organization and the point of connection between clients and the organization. It should have enough qualified staff and complete information. Work control staff are planners,

inspectors, estimators, and those who prepare work orders (25). The work control center functions and staffing can be classified into the following:

1. **Work Control Responsibilities**

Responsibilities of work control include:

a. Work request reception

b. Facility inspection

c. Planning and estimating

d. Work order preparation

e. Support for long-term planning for Projects & Budgeting

f. Data feedback for administration.

2. **Effectiveness Evaluation**

In the work control room work conducted by each workshop should be reviewed, productivity should be measured, and quality and economic effectiveness should be evaluated (4).

3. **Work Reception Training**

Work control staff must be well trained in the nature of maintenance jobs, so that they can understand the problem from the requester and respond to it correctly.

4. **Planning Staff**

Expert technicians should be recruited in work control to conduct estimating, planning and inspection jobs (4,25).

5. **Management Analysis**

Analysis should be conducted in work control for reviewing, evaluating and making suggestions for improvement of the work. Work control should be given more attention and put under a higher authority to give it support to achieve its mission (4,7,25).

3.1.4 SHOP ORGANIZATION

Every shop needs a documented line of authority, and relationship with other workshops. For effectiveness of production, each workshop's organization is checked and reviewed. Shop supervisors and staff must be well trained for safety (4,7). To check the shop's organization the following should be checked:

1. **Shop Functions**

Each unit's function, responsibilities and lines of authority should be documented and clarified to the shop personnel (4,17).

2. **Related Crafts Relationships**

Related crafts should share information and work together as a team to provide optimum services (4,5).

3. **Effectiveness Evaluation**

Workshopss effectiveness must be reviewed periodically. Shop organization advantages and disadvantages are studied to recommend necessary actions to increase effectiveness of the workshop (1,4,6,11).

3.1.5 SHOP SUPERVISION AND PLANNING FUNCTIONS

During auditing the ratio between supervisor and workers and the availability of a planner to schedule the shop work is checked. These checks affect the result of the auditing and its final recommendation. In the study of shop supervision and planning functions the following should be considered:

1. **Multi-Craft Job Coordination**

Shops carry out many types of jobs, and coordination and supervision of these multi-craft jobs is the responsibility of workshop supervisors. Managers should clarify and help personnel to improve coordination.

2. **Supervision Coverage**

The work of the shop should not be affected by the absence of the supervisor. Each shift should be supervised by a qualified foreman.

3. **Planning Function**

Each shop should have planners to help the supervisor to schedule the work, coordinate with other workshop, and control materials and manpower (4,5).

3.1.6 FIRST LINE SUPERVISORS & THEIR RESPONSIBILITIES

First line supervisors are recommended to be responsible for 12 to 15 workers: to organize their department and increase their efficiency (7,25). Some factors affecting this issue are:

1. **Supervisory Ratio**

The ratio of workers to supervisors must be reasonable to allow supervisors to spend more time to direct their people (4,7,25).

2. **Availability of Adequate Support Staff**

The availability of an adequate number of qualified technicians helps supervisors to manage their sections and distribute responsibilities. A strategic plan should be there to provide the maintenance department with required resources (7,9).

3. **Labor Productivity**

One major responsibility of supervisors of maintenance is to follow and improve labor productivity. A standard man-hours/actual man-hours should be considered. Also training should be given to each employee to achieve a desired productivity (1,12,25,26).

3.1.7 TRAINING

Training is an important factor affecting the efficiency, production and quality of performance of workers. The following are two types of training which should be conducted with maintenance personnel:

1. **Technical Training**

Maintenance supervisors are trained to improve their ability of supervision. Employees also are trained regularly to get more knowledge and increase their productivity. Each section and workshop should summarize their need for training. The minimum required training for each employee every year should not be less than 5 days (7,19).

2. **Productivity Training**

Training is not for supervisors or workers only, but also for higher management levels. Productivity training is required both formal and on the job site (25).

3.2 WORK LOAD IDENTIFICATION & PERFORMANCE MEASURES

Work requests and completion of work must be documented to show the maintenance management how busy each section is the department and to keep feedback records for future needs. In addition, performance measures should be identified and published continuously (2,7,14,25). This component is composed of the following elements:

- Facility Condition Inspection
- Work Request Procedure
- Relationship between Sections
- Preventive Maintenance (equipment)
- Service Work
- Routine, Recurring Work
- Work Requirements Documentation
- Performance Indicators
- Publishing Maintenance Performance

3.2.1 FACILITY CONDITION INSPECTION

When construction work is inspected by experts, suitable remedial work is suggested, and priority is given to conducting the repair work according to

the condition and severity of the required maintenance work (3,7,12,17). The facility condition inspection includes:

1. **Inspection Staff**

One major task of maintenance work is to inspect construction. Availability of qualified inspectors is very important to give feedback reports to maintenance management to plan and schedule the suitable remedies (12). One inspector at least is needed to cover 2,000,000 square feet every two years (4).

2. **Inspection Scheduling**

Inspection work should be scheduled on a cyclic basis. Advantages of regular inspection can be reflected in better safety, health and environmental conditions. Diagnostic routines also should be used regularly on mechanical systems in the building, such as air conditioning (4,7,12,25).

3. **Maintenance & Repairs Based on Inspection**

The facility condition inspection report is important to maintenance management in order to do the maintenance and repair work based on the report. The early repairs can retain the asset in a better and safer condition and save a lot of expense (4,12,22).

3.2.2 WORK REQUEST PROCEDURE

The procedure for any work request starts from the requestor, and is received by the control room. A work order is initiated, then the work is conducted and a feedback report is sent to the work control room (1,4,7,12,17,25).

These issues are very important, affecting work control from initiation till the work order is closed.

1. **Work Order System**

A work order system is a very important tool in each maintenance organization. It helps in controlling materials, follow-up of labor productivity, planning and scheduling. A work order form is usually filled by work control and coordination personnel after receiving the work request from the user (12,25). Basic items of information that should be available in the work order form are (12,25):

a. Serial number, date of request.
b. Name of requester.
c. Priority of the request
d. Description of the work
e. Workshops requested to conduct the job
f. Material required
g. Man-hours required

2. **Procedure Documentation & Processing**

In documentation of work requests, procedure is necessary to give feedback and plan the work. Historical data is needs to be reviewed and analyzed to improve and increase the maintenance performance (4,8). The process of the work request can be followed and controlled by the work order form if it is applied correctly (4,25).

3. **Feedback to Requester**

Feedback is given to the requester that his request has been received, action will be taken as specified, on such and such a date (4).

3.2.3 RELATIONSHIPS BETWEEN SECTIONS

A clear and practical relationship between different sections is understood and documented for ease of conducting jobs and to optimize the work product. Any points of confusion must be clarified and explained by management so that the work is not affected (4,7,8). Three factors have a direct effect on relationships between sections, namely:

1. **Personnel Understanding of their Works Relationships**

Maintenance work is classified into many trades. No section or division can work alone without the help of others, so it is expected that all maintenance staff are trained to understand the relationship of their work to achieve the mission of their organization (7).

2. **Job Description of Each Section**

To identify a better relationship between sections, the job description should be clear and understood for each section. The work order system can not be implemented unless each worker knows each section's responsibilities and duties (25).

3. **Team Work Assignment**

In some cases such as shutdowns or overhaul maintenance and replacement, a team made up of different trades is assigned to conduct the job. A leader is

assigned to that assignment to be responsible on behalf of the management till the project is completed.

3.2.4 PREVENTIVE MAINTENANCE (EQUIPMENT)

In order to keep equipment working in a good condition, it should be checked and maintained regularly. Preventive maintenance covers about 10% of documented maintenance work. Preventive maintenance works are documented for each piece of equipment, to get feedback when needed for that equipment (1,4,7,8,12). The following should be considered in the preventive maintenance program for equipment:

1. **Planned Preventive Maintenance**

Records and feedback reports are used to plan, organize and carry out the maintenance work.

2. **Preventive Maintenance**

This is defined as: "Maintenance carried out at predetermined intervals or to other prescribed criteria and intended to reduce the likelihood of an item not meeting acceptable conditions" (12).

3. **Running Maintenance**

This type of maintenance is carried out when the equipment or the item maintained is working (12).

3.2.5 SERVICE WORK

Service work as defined by Applied Management Engineering, PC and Harvey H. Kaiser (4) is "small, single-craft jobs which require less than four

hours each to complete. These jobs are generally not appropriate for scheduling individually and should be processed differently from other types of work". It is important to calculate the percentage of service works to the total maintenance work to balance staffing of these jobs (4,11,13). The service work auditing includes the following three factors:

1. **Service Work Classification**

Scheduling and planning of work requires classification of the work to be conducted. Service jobs are processed separately from other types because of their nature (4).

2. **Processing Procedures**

The processing procedure evaluation is based on the following (4):

a. Where requests are received

b. Is there screening and determination of priorities?

c. Is there a system to follow-up uncompleted service work?

d. Is feedback information sent to the requester?

3. **Work Load Analysis**

Analysis is done to find out the ratio of total work force to those doing service work. Also analysis helps to balance the distribution of manpower between service works and other maintenance types (4,7,12).

3.2.6 ROUTINE, RECURRING WORK

Repetitive work, such as maintenance of kitchen equipment is routine work (4). These jobs are expected to be requested periodically so that

maintenance personnel can be ready to conduct them. When these jobs are planned, conducted and reviewed, the following are considered:

1. **Recurring Work Classification**

Recurring work is classified and controlled separately from other types of work.

2. **Standing Work Order Scheduling & Performance Report**

Work orders are scheduled weekly to accomplish $\pm$10% scheduled hours. A performance report is sent to the management periodically to review and recommend improvement actions (4,7).

3. **Activity Cost**

The cost of time and quality for maintenance procedures are measured and checked routinely (7,8,15).

3.2.7 WORK REQUIREMENTS DOCUMENTATION

Maintenance work should be documented and kept in reachable records to be used for future feedback. Maintenance problems, deficiencies, forms and procedures also listed to make the review of priorities and workload easier (4,7,12,25). The most important types of work requirements documentation are:

1. **Prioritization**

Priorities can be set considering the cost and craft hours. The jobs are sorted and summarized by priority, type of work and fund resources (4,7,25).

2. **Summaries of Status**

Jobs are summarized by their status; some important notes are documented such as date of start and completion, required materials, planning, etc.

3. **Work Load Review**

The work load should be reviewed periodically using periodical reports and feedback information to reach a suitable action for improvement (4,7,12).

3.3 WORK PLANNING & SCHEDULING

The objective of work planning is to develop a strategy to conduct the work in a fixed period with successful completion. The methods of performing the work are evaluated, flows of work are controlled, and performance in effective time and cost are some of the planning corners. Shutdowns, weekly jobs and preventive maintenance should be scheduled using critical path or other methods (7,25). The following elements belong to this component:

- Priority System
- Work Classification and Weekly Schedule
- Alterations & Improvement Work
- Budget Requirements for M&R
- Budget Execution Plan
- Backlog of Funded Work
- Emergency Work & Shutdown Scheduling

3.3.1 PRIORITY SYSTEM

The priority system in most maintenance organizations is classified into three categories, First, Second and Third priority, as explained in the Literature Review. The priority system is mainly composed of the following three factors:

1. **Criteria Documentation & Distribution**

Priority criteria should be established in the organization, documented and distributed. All maintenance supervisors, inspectors and planners should be aware of the criteria for priority (4,8).

2. **Criteria Appropriateness**

The criteria should consider some important factors, such as safety, energy conservation, economic issues, etc. (4,27). These factors should be appropriately addressed.

3. **Consistency of Priority Criteria**

Consistency is important in establishing the priority system. When jobs are planned and priority criteria are consistent, the workflow will be conducted easily and systematically.

3.3.2 WORK CLASSIFICATION AND WEEKLY SCHEDULE

Based on the experience, condition and standard, the required work is classified as normal, urgent or emergency (1,12). In order to conduct jobs, some statistical analysis is done to program daily and weekly jobs. Weekly scheduling can be done for ordinary and urgent jobs based on classification

and priority listing for requested works (1). The following are the work classification and weekly scheduling issues:

1. **Work Classification**

As mentioned earlier in the case of scheduling, planning and controlling the work it is important to classify this work into many types, such as service work, preventive maintenance, recurring work, etc (4,8). If this classification is done, it will help in scheduling and planning the work.

2. **Work Processing Procedure**

The processing is started by filling forms such as the work request form and work order form, then actions are taken till the work order is closed and data are entered in the system (4,7,12,25).

3. **Weekly Scheduling**

Jobs are scheduled and planned for long-term plan, for mid-term plan and for short-term. Weekly scheduling should be set by the supervisor of each section for routine maintenance work requests (12).

3.3.3 ALTERATIONS AND IMPROVEMENT WORK

Naturally some buildings need some alterations or improvement maintenance work such as re-arranging partition walls, changing locations of doors or demolition of some walls to increase space (1,4,12). As this issue is an important factor, it consists of the following elements:

1. **A/I Classification**

Clear classification should be given to alterations and improvement jobs to distinguish them from maintenance jobs (4). However it is not easy to distinguish clearly between maintenance and improvements. The improvement jobs are initiated by design faults or necessity for higher standards. Alterations are also required when the use of the building is changed (12).

2. **Work Processing and Programming**

The processing of the work should be determined by many regulations, such as the source of funding (4,12).

3. **Work Force Distribution**

The percentage of improvement and alteration jobs to maintenance work should be reasonable. The Planning budget also should be considered for improvement work separately from maintenance work (4,12,27).

3.3.4 BUDGET REQUIREMENTS FOR MAINTENANCE & REPAIRS

The following are the most important factors composing the budget requirements for maintenance and repairs of buildings:

1. **Budgetary Method**

Annual maintenance budgets for maintenance and repairs are estimated using (1,7,31):

a. Feedback reports and activities planned
b. Fixed formula approach
c. The last year's budgets

Othoman, Nixon and Lofgren summarize four factors for budget estimating for facility maintenance and repair (27):

a. Physical plant initial or replacement cost.
b. Formulas for quantifiable attributes of the plant
c. Life cycle analysis
d. Assessment of facilitiess physical condition.

2. **Cost Reporting & Budget Documentation**

Each type of maintenance work should be reported separately from others. Indication of the cost of each type is recorded for ease of analysis and estimating of next year's budgets. Project works are accounted separately from the maintenance account. The annual budget estimating and scheduling of overhaul data should be documented and reported for feeback for later years (4,7,27).

3. **Long-range Requirements**

Long range requirements, such as renewal and replacement of some items of the building are considered for budgeting preparation (4,12). The long-term plan is set for five or more years. Its objective is not to lay down each small job but to give an idea and budget estimation for major projects that will be conducted in the coming five or more years (12).

The required maintenance and repair budget can be estimated from:

- Past records feed back
- Long term planning for work
- Condition-based survey
- Using some formulas

Expert and reasonable estimation must be done to get a satisfactory budget for maintenance (1,4,12).

3.3.5 BUDGET EXECUTION PLAN

Maintenance managers and engineers are responsible for how the budget is spent. They should have a very clear plan to utilize the budget professionally. Good judgement and experience, and planning will help in maintaining facilities without wasting of resources (4,27). The following are related to the budget execution plan:

1. **Periodic Budget Execution Planning**

The execution plan of the budget can be documented monthly or a longer-term basis (4,7).

2. **Identification of Work Types**

The work class and types are identified by the plan, and all types of maintenance works are included in the plan of execution of the budget (4,7).

3. **Budget Controls**

Expenditure of the budget should be controlled adequately. Reports of actual expenditure are compared with the planned expenditures. In general, budgets are executed within $\pm$10% (4).

3.3.6 BACKLOG OF FUNDED WORK

Management should be aware of or reported to periodically about funded work. These summary should include priority, trends and analysis to review

work (4). For the backlog report of funded work, the following factors should be considered:

1. **Backlog Definition**

Work backlog should be defined, also the backlog of funded work should be documented, summarized and reported periodically (4,7,25).

2. **Backlog Summaries**

Work backlogs are summarized according to their shops, type of work or by priority (4,7).

3. **Backlog Review and Analysis**

To take corrective actions the work backlogs are reviewed periodically and problems are investigated (4).

3.3.7 EMERGENCY WORK & SHUTDOWN SCHEDULING

This factor of building maintenance management auditing is composed of the following:

1. **Non Emergency Work**

Good planning and scheduling for preventive maintenance will minimize the emergency work (1,4,15,22,28). An increasing number of emergency jobs affects the planning and scheduling and indicates the deterioration of the maintenance system, in addition to the disturbance it causes to clients.

2. **Standard Time Assessment**

Breaking the work into elements and counting the time each element takes to execute will help to know the standard time these jobs will need. Standard

time is determined by the performance a qualified worker can achieve in a regular working hour as an average (6,8,12).

3. **Shutdown Scheduling**

Long-term scheduling for shutdowns should be made for preventive maintenance purposes, such as, for air conditioning stations, water pumps and electric generators. The schedule should be clear and announced to clients. A suitable time is selected for shutdowns to cause no disturbance for users and occupants (13,22,25,29).

4. **Long Term Plans**

The idea of long term plans is not to determine what to do exactly on an exact date, but to estimate needed budgets in advance for up to 5 or more years. This budget includes needed structures, staff and time to carry out major maintenance work and repairs (12).

3.4 WORK ACCOMPLISHMENT

This section describes some types of support activities that help maintenance organization to do their work efficiently. Following are the elements which constitute this component:

- Shop Scheduling & Planning Procedures
- Craft and Material Availability
- Maintenance Process & Re-Engineering
- Shop, Spaces, Tools & Equipment
- Transportation

- Supervisory Practices
- Use of Contracts

3.4.1 SHOP SCHEDULING & PLANNING PROCEDURES

To achieve the goal of a workshop the formal function is established, jobs are scheduled and processed on weekly basis (4). This factor can be divided as follows:

1. **Scheduling Established**

Each shop should have a weekly scheduling for its works according to the work orders received. These scheduling procedures are identified and documented (4,25).

2. **Scheduling Procedures**

Meetings are held to ensure understanding, agreement and coordination. The manager of the maintenance department and the shop head participate in the scheduling process, and feedback should be received from the workshops about the work accomplishment (4).

3. **Scheduling Performance**

The scheduling performance allowed is within $\pm$10%, and if it is not within this range, corrective actions should be taken (4,25).

4. **Shop Planning Support**

The support of shop planning is given by ordering the material, delivery of material to the work site, equipment and tools, work site availability and

other supports needed, such as information and technical data, etc (4,8,12,25).

3.4.2 CRAFT AND MATERIAL AVAILABILITY

Qualified staff are recruited by maintenance management to achieve a better performance. Another important factor affecting quality of work accomplishment is material resources such as: technical documentation, inventory systems, tools, machines and spare parts (1,4,7,8,12). The following are factors related to craft and material availability:

1. **Craft Distribution Planning**

The weekly plan of the workshop includes the scheduling of the work force. Shop hours are identified from other classes of work (4,7,8).

2. **Work Ordering Scheduling**

Work order is necessary for scheduling and controlling the workshop jobs and its implementation helps the workshop supervisor to control jobs successfully (4,12,25).

3. **Material Scheduling**

Before scheduling each work order, the materials needed are determined. Especially for large jobs, material availability is very important before the start of work (4,8,12,25).

4. **Material Availability**

It is difficult to schedule work or to start it without material. The workshop can not operate unless material resources are available (4,8).

3.4.3 MAINTENANCE PROCESS RE-ENGINEERING

Maintenance process re-engineering is applied in maintenance processes design such as planning, identification of corrective maintenance and redesign of key processes to optimize utilization of maintenance resources.

Automation of maintenance management and work procedures, technical support processes, and activity costs are also parameters of maintenance process re-engineering (4,7,8). The maintenance process re-engineering is related directly to the following factors:

1. **Key Maintenance Processes are Designed**

Key maintenance processes are designed to increase efficiency and reduce wasted time. Planning of work accomplishment is clarified on maps to be followed by maintenance workers (7).

2. **Work Process Automation**

Computers can be utilized in controlling work by the work control and coordination office, workshop supervisors and managers (25). A lot of information technology development can help to improve maintenance practice (9).

3. **Quality Cost Measuring**

The quality relates to the condition of the building considering the age and its initial specification. The age factor assumes a constant value for the first 15 years of a building's life (12). Information systems and automation of maintenance work help in quality measuring and monitoring.

4. **Performance Indicators**

There are some indicators which show whether functions of maintenance and its performance are in control or some actions need to be taken. These indicators must be linked to the objectives and strategy of the maintenance organization (11). Maintenance performance indicators are taught, pasted and published regularly to be understandable to each worker (7).

3.4.4 SHOP, SPACES, TOOLS AND EQUIPMENT

Enough spaces are given for shops in adequate locations. These shops should be provided with needed tools and equipment (4,25). Also the following factors should be considered:

1. **Shop Spaces**

The shop location should be suitable to get the most efficiency of the work force. The work shop should not be far away. The size of the workshops, facilities and storage must be convenient for better performance (4,7).

2. **Tools and Equipment**

Tools and equipment are essential for workshops. The tools and equipment must be maintained and restored properly. A record for them and their repairs is important. Preventive maintenance should be scheduled for equipment and assets (25). Equipment is classified according to its importance to safety and operations (7).

3. **Shop Conditions**

The workshops and their facilities should be maintained continuously to keep them in a good condition (4).

3.4.5 TRANSPORTATION

The nature of maintenance work requires a lot of travelling, especially in large organizations. For this reason an adequate number of vehicles is needed to drop workers and take them back from the work sites. Transportation has an important effect on maintenance workers' performance. It also an effect on a decision as to whether maintenance organization starts to assign groups in remote areas or not (1,4,12,25). These are some aspects to be considered during the evaluation of transportation facility:

1. **Adequate Number of Vehicles**

Availability of enough vehicles is necessary for maintenance personnel to move from one site to another. Delays in moving laborers will affect their performance and productivity (1,4,12).

2. **Operation & Maintenance**

To be sure that vehicles are in good condition, they must be serviced and maintained adequately (4).

3. **Tools & Equipment**

Tools and equipment are provided in vehicles to make field work easier and to minimize travelling and wasted time (1,4).

4. **Utilization Reporting**

Requirements of vehicles and their equipment is planned within the budget of the maintenance organization. It is important to recognize and document their need and economic use (4).

3.4.6 SUPERVISORY PRACTICES

Supervisors are the first line of maintenance management. They are expert in their field and carry out the responsibility of directing workers towards achieving a good quality product in specific time. Another responsibility of supervisors is to help workers, train them, and supervise safety issues in workshops (1,720,25,30,31). Supervisory practices are composed of the following factors:

1. **Direct Supervision**

One of the measures of planning efficiency is the supervision factor, which directly affects the productivity (12). Direct supervision requires that the supervisor will spend most of his time with laborers to lead them, instruct, train and control (7,20,25).

2. **Supervisory Responsibilities**

Supervisors are responsible for quality of work, evaluating work performance, guidance of technicians, reporting and documenting variances between planned and actual hours. Supervisors are responsible management for their workshops (12,20,25).

3. **Training and Safety Programs**

As mentioned previously in this chapter, it is important for supervisors to train themselves and identify suitable training for their personnel. Also, safety is very important issue, so safety should be considered in training and practices of workshops (4).

4. **Labor and Material Costs**

A workshop supervisor is responsible for accounting and documentation of the cost of maintenance jobs, including the cost of labor and materials (1,4,7,12).

3.4.7 USE OF CONTRACTS

Maintenance departments can operate their organizations independently or they can depend partially or heavily on contractors. There are some specific jobs preferred to be let to contractors and others preferred to be done by direct maintenance labor according to advantages and disadvantages of each type. If maintenance jobs are let to contractors some tests should be done for the contractor laborers to ensure their qualifications. In addition, a periodical review is to be conducted to evaluate many characteristics such as quality, flexibility and reliability of that contractor (1,4,6,12,25). For better use of contracts the following should be considered:

1. **Balancing Contracts and In-house Staff**

Cost, quality and convenience will be considered when decisions are made as to whether that the work will be done by contractor or by direct labor. It cannot be decided till advantages and disadvantages are reviewed for each type, and the decision depends on the amount and type of work. Choice is also influenced by the nature of work, volume of work, response time, location, quality, availability of spaces, market conditions and cash flow (12).

2. **Contract Administration**

The contractor is expected to be professional and expert to manage the contract. The contractor administrator should be experienced and well trained (4,12).

3. **Contract Performance**

Quality assurance requires follow-up and monitoring of the performance of contractors to achieve the planned objective (4,11,12).

4. **Management Evaluation**

Evaluation and cost comparison should be made between contract or in-house maintenance performance to guide management to the right decision (4,12).

3.5 INFORMATION TECHNOLOGY & APPRAISAL

There should be an easy maintenance management system. Managers and supervisors must be aware of the system in order to automate data analysis and forecasting (7). The appraisal component summarizes the information system features needed for comparing planned with actual results (4). Elements which build this component are listed below:

- Management Information System (MIS)
- Measurement of Performance
- Productivity Measurement
- Information Systems & Historical Records

- Variance Review

3.5.1 MANAGEMENT INFORMATION SYSTEMS (MIS)

Nowadays management work is becoming complicated, and manual methods of operation can not accommodate the problems of management with the volume of today's business. Maintenance controls, planning, scheduling and inventory require a Management Information System to be applied. Information Technology (IT) is used actively for maintenance and its uses are increasing. In the future it is expected that IT will be utilized to help to improve every activity of maintenance practice (4,7,9,22,25,27). The following factors are the most important factors composing a good Management Information System:

1. **MIS Adequacy**

There should be clear objective of collecting databases and starting information system. Also it is important to establish proper procedures and techniques for the information. Establishment of a Management Information System is done with reports distributed periodically (4,7,9,12).

2. **Report Design and Utilization**

Reports should be designed to be accessible and easy to use by all levels of maintenance management. Planners and schedule makers should be aware of the system and able to utilize the system to do their jobs (4,7).

3. **Facility and Equipment Reports**

Historical reports and data can be linked to facility and equipment records. The stock records need to be accurate and condition-based maintenance is

automated and analysis of data is programmed using the management information system (MIS) (4,7,9).

4. **Ease of Maintenance Management System**

A maintenance management system should be easy to use and clear, since it will be used for many aspects of maintenance practices. The following topics will be covered by Information Technology (9):

- Setting maintenance objectives
- Maintenance planning
- Maintenance management resources
- Evaluation of maintenance performance.

Unless the system is workable and easy to use, staff will be stuck in handling their jobs, affecting the performance badly.

5. **Using Expert System**

Expert system is a program which contains an interface engine and empty knowledge base which can be filled. This system can be used as one part of an integrated system. It helps in some cases, like that an expert system assures using spare parts in the right places (9). Also expert systems are used for diagnostics of complex problems (7).

3.5.2 MEASUREMENT OF PERFORMANCE

Performance measuring is a key component of maintenance management and maintenance management audit (please see 2.1.2 in this chapter). Performance should be assessed and measured regularly to notice any

deficiency and conduct improvement actions. The assessment and measurement should consider the following:

1. **Performance Measurement Methods**

As mentioned previously in this chapter, performance is measured by many methods. It is generally not easy to measure maintenance performance. There are not only quantifiable parameterss but also the quality of the work performed (4,8,12). The quality of maintenance performance is audited through four stages (8):

a. Survey of prevailing situation of the influencing parameters.
b. Analysis of conclusions and recommendations
c. Setting of priorities and plan of action
d. Analysis of the cost for justification of the proposed actions.

2. **Report Summaries**

Reports are very important feedback for management, to review, audit, improve and to take necessary decisions. Reports of performance are compared with targets for work force distribution. Also work scheduling priority and backlog reduction should be reported regularly (4,7,8,25).

3. **Engineered Performance Standards**

Activity costs of man hours and laborers should be estimated, using work order forms, and costs of quality should be measured routinely (4,7,25).

4. **Improvement Studies**

Improvement studies should be conducted for craft work performance. An efficiency study will lead to professional recommendations if it coincides with periodical assessment of the maintenance performance (4,8).

3.5.3 PRODUCTIVITY MEASUREMENT

The productivity of maintenance laborers is one of the most important factors of maintenance management, as mentioned earlier. Productivity is measured by reducing unit costs to improve efficiency. It can also be measured by the quality and volume of a laborers' output in return for paid wages. An important factor helping to increase the productivity is the availability of data and planning the work before starting the execution of that work (5,8,9,12,21,22). The measurement and study of productivity include the following:

1. **Productivity Study Frequency**

Frequent assessment of manpower productivity is one parameter of measures of performance. The productivity study of any workshop should be conducted periodically (4,12,25).

2. **Work Sampling**

The study of productivity measures requires a sampling of representative parts of work done by the workshops (4).

3. **Comparisons**

Work sampling can be compared with targeted productivity by breaking down a job into its components and time of execution of work (4,12).

4. **Improvement Action Plan**

After reviewing the reports of the productivity study and doing the comparisons of targeted with actual productivity an action plan is put forward to improve the productivity (4,8,12).

3.5.4 INFORMATION SYSTEMS & HISTORICAL RECORDS

Information technology can help maintenance personnel considerably to store, transmit, process and retrieve data when needed (20). Information technologies are already used widely in maintenance management (9). The following records are the main components of information systems and historical records:

1. **Facility History Records**

Historical records are very useful for information feedback in the future for preventive maintenance, problem diagnostics, review of problems, improvement studies and reports, and budgeting and managerial purposes. Information technology can be utilized instead of manual filing which consumes a lot of effort and time. Completed work orders, updated information, summarized reports should be filed for future needs (1,4,7,9,12).

2. **Equipment History Records**

Previous jobs and maintenance work (both corrective and preventive) are important to document. Historical information is needed in detail especially for equipment, since its failure can cause a lot of inconvenience and cost. Also instructions of how to operate and maintain equipment, drawings and manuals are necessary to keep in a record (1,4,7,9,12).

3. **Spare Parts Information**

Parts information should be available, understood and accessible. It is very important to keep catalogues and manuals provided by suppliers are very important to keep them in files. Parts information should also be linked to equipment records for ease of replacement. Usually they are stored according to suitable stock orders to reach them as they are needed (1,4,7,9,12).

3.5.5 VARIANCE REVIEW

The management information system is utilized to compare actual with planned practices. Continuous evaluation and auditing of a maintenance system helps in reviewing the variance and recommending suitable suggestions and plans for improvement actions (4,6). The variance review includes the review of the following:

1. **Variance Review Policy**

Current practices are reviewed and compared with planned activities (4). The good planning of the work will result in less variance between actual and planned work. The variance review policy will result in good feedback of information to the maintenance management.

2. **Review of Responsibilities**

Responsibilities and duties are reviewed according to determined parameters defining subjects and guidelines for these reviews. Also supervisors' and managers' responsibilities are reviewed and variances between their planned and actual activities and responsibilities are studied and reviewed (4).

3. **Variance Records**

To reduce the recurrence of variance between planned and actual activities, records and data are used and studied to recommend and take a decision on the suitable action (4,6,8,13).

3.6 MATERIAL MANAGEMENT

Parts and materials should be available, ready to use and accessible when needed. The inventory is reviewed regularly to get rid of obsolete and unused materials. Management should be systematic in issuing purchase orders for materials and spare parts (7). Elements comprising this component are as under:

- Parts & Material Availability
- Store Room Operation
- Tools & Material Management Using Information Technology
- Inventory Functions & Costs

3.6.1 PARTS AND MATERIAL AVAILABILITY

Spare parts and material are considered to be available but at the same time it is not right to store more than is needed. If good inventory techniques are used, no excess need material will be in the stock (1). The following three factors are related to the parts and material availability:

1. **Stock Outs**

Material should be always available for continuous service. It is assumed that stock outs orders are less than 3% of orders placed (7).

2. **Inventory Review**

The inventory management is responsible for material storing, availability, place of storage, methods of storage and when economic purchase orders are to be issued (20).

3. **Work Order Scheduling**

Before scheduling any work, planners and schedule makers should be sure that needed materials are available. For a large project or overhaul works materials are reserved prior to start of the work (1,4,12).

3.6.2 STORE ROOM OPERATION

When talking about the storeroom operation many parameters are considered, such as: storeroom security, safety, procedures systems, and material management (4,6,7). These important factors are briefed as follows:

1. **Store Room Control Procedure**

Nowadays, the materials purchased by maintenance organizations are many and from different types of trades. To control the material, information technology can help in automation of more and more production of equipment and material. Also it is an objective of maintenance management to get the maximum service level with minimum spare parts which can be achieved by better control of material resources (6,9).

2. **Security and Accessibility**

The storeroom for each workshop should be in a secure place and accessible to the shop (1,4).

3. **Safety of Stock**

The first consideration of maintenance management activities is safety, such as storing materials in safe places. Flammable, hazardous material and health harmful materials are given special attention in storing and handling (1,8,20).

4. **Salvage and "Bench Stack" Controls**

Material control requires a continuous salvage program integrated with inventory management. There should be categorization of materials and numbering according to stocks (1,4,32).

3.6.3 INVENTORY FUNCTIONS AND COSTS

"Inventory is broadly defined as any stock of economic resources that are idle at a given point in time" (33). The objective of material management is to reduce inventory to the lowest possible level. The cost criteria in inventory management are covered by the following (1,33):

1. **Ordering Costs**

The order cost is counted in terms of cost per order, and the costs include purchase order, transportation, receiving, inspection, placing in storage, auditing and payment to suppliers (1,33).

2. **Carrying Costs**

Carrying costs are the costs of holding a stock of material on hand. It is counted as the cost of carrying one unit of inventory for one year (1,33).

3. **Shortage Costs**

These are the stock out costs. It happens when the needed quantity of materials exceeds the supply of material in hand. This requires a back order demands and costs for the delay accrued because of shortage of materials (1,33).

Table 3.1 Key Elements of Maintenance Management Auditing

First Component: Organization & Human Resources

No.	Questions
A.	**Organization Structure**
1.	Availability of organization chart
2.	Availability of function statements for all components which define roles, authority & responsibility
3.	Job description for each position
4.	Data updating procedure
B.	**Policies, Rules and Services**
1.	Availability of general policies and objectives documentation
2.	Complete services organization clearly defined
3.	Availability of active updating procedure
C.	**Work Control Center Functions, Staffing**
1.	Clear work control responsibilities.
2.	Effectiveness evaluation and review
3.	Work reception staff training
4.	Planning staff sufficiency
5.	Establishing of data analysis for management use
D.	**Shop Organization**
1.	Availability of documented shop functions
2.	Clear related crafts relationships
3.	Effectiveness review and evaluation
E.	**Shop Supervision & Planning Functions**
1.	Multi-craft job coordination
2.	Supervision coverage adequacy
3.	Establishment of planning functions to support shop supervisors
F.	**First Line Supervision & Responsibilities**
1.	Ratio of supervisors to craft workers
2.	Availability of adequate support staff
3.	Labor productivity follow-up
G.	**Training**
1.	Technical training
2.	Productivity training
3.	Management training
H.	**Motivation**
1.	Conducting a climate survey

No.	Questions
2.	Annual turnover due to quits and discharges of laborers
3.	Employees' financial motivation
4.	Employees' awards and recognition
5.	Less barriers between labor and management

Second Component: Work Load Identification & Performance Measures

No.	Questions
A.	**Facility Condition Inspection**
1.	Availability of inspection staff
2.	Availability of documented inspection scheduling
3.	Conducting maintenance & repairs based on inspection
B.	**Work Request Procedure**
1.	Availability of work order system
2.	Availability of documented procedure
3.	Information feedback to requester
C.	**Relationship Between Sections**
1.	Personnel understanding of their work relationships
2.	Job description of each section
3.	Team work assignment for the same jobs
D.	**Preventive Maintenance (Equipment)**
1.	Planned preventive maintenance
2.	Accomplishing preventive maintenance work within 10% of schedule
3.	Periodically reviewing equipment history records.
E.	**Service Work**
1.	Classifying service work separately from other work
2.	Clearly documenting processing procedure of service work
3.	Conducting work load analysis
F.	**Routine, Recurring Work**
1.	Classifying recurring work to be controlled separately
2.	Reporting standing work order scheduling & performance weekly
3.	Cost estimation of recurring work
G.	**Work Requirements Documentation**
1.	Establishing prioritization of all work
2.	Summarizing jobs by status
3.	Reviewing work load periodically

Third Component: Work Planning & Scheduling

No.	Questions
A.	**Priority System**
1.	Documentation & distribution of priority criteria
2.	Appropriateness of priority criteria
3.	Consistency of priority criteria
B.	**Work Classification and Weekly Schedule**
1.	Work Classification for all tasks
2.	Developing and implementing work processing procedure
3.	Weekly scheduling for conducting work
C.	**Alterations and Improvement Work**
1.	Classifying alterations and improvement separately from maintenance work
2.	Processing and programming of work separately from maintenance
3.	Distribution of work force within a planned target
D.	**Budget Requirements for Maintenance and Repairs**
1.	Planning annual maintenance budget
2.	Cost reporting & budget documentation
3.	Formally identifying and presenting long-range requirements for renewals and replacement to financial managers
E.	**Budget Execution Plan**
1.	Establishing periodic budget execution planning
2.	Identifying work types in the budget plan.
3.	Controlling budget against expenditure
F.	**Backlog of Funded Work**
1.	Defining accepted and applied backlog
2.	Backlog summaries of approved work
3.	Backlog reports review and analysis
G.	**Emergency Work & Shutdown Scheduling**
1.	Minimizing emergency work occurrence
2.	Standard time assessment for specific jobs
3.	Shutdown scheduling and planning
4.	Long term plans

Fourth Component: Work Accomplishment

No.	Questions
A.	**Shop Scheduling & Planning Procedure**
1.	Establishing weekly scheduling
2.	Documenting & reviewing scheduling procedures weekly
3.	Performance within ±10% of planned works
4.	Shop planning support availability
B.	**Craft and Material Availability**
1.	Craft distribution planning for shop workforce
2.	Work ordering scheduling for craft hours
3.	Material scheduling for individual work orders
4.	Material and equipment availability
C.	**Maintenance Process Re-Engineering**
1.	Designing Key maintenance processes
2.	Work process automation
3.	Quality cost measuring
4.	Establishing performance indicators
D.	**Shop, Spaces, Tools & Equipment**
1.	Shop space adequacy
2.	Tools and equipment adequacy
3.	Maintenance of conditions in shops and facilities
E.	**Transportation**
1.	Adequate number of vehicles for maintenance transportation
2.	Adequate operation & maintenance of vehicles
3.	Tools availability
F.	**Supervisory Practices**
1.	Spending high enough percentage of supervisor's time on direct supervision
2.	Clear supervisory responsibilities
3.	Identifying training & safety programs by supervisors
4.	Labor and material cost estimation
G.	**Use of Contracts**
1.	Balancing contracts and in-house staff
2.	Contract administration by experienced and trained personnel
3.	Monitored contract performance
4.	Frequent management evaluation and comparisons between contract and in-house performance

Fifth Component: Information Technology & Appraisal

No.	Questions
A.	**Management Information Systems (MIS)**
1.	Maintenance of MIS adequacy
2.	Report design and utilization
3.	Facility and equipment reports
4.	Easy to use maintenance management system
5.	Using expert systems
B.	**Measurement of Performance**
1.	Using performance measurement methods
2.	Report summaries preparation
3.	Using engineered performance standards to estimate labor hours on work orders
4.	Conducting improvement studies
C.	**Productivity Measurement**
1.	Frequent productivity studies
2.	Conducting work sampling of representative shop workforce
3.	Comparisons of various categories of work
4.	Conducting improvement action plan
D.	**Information System & Historical Records**
1.	Availability of facility history records
2.	Availability of equipment history records
3.	Spare parts information
4.	Computerized inventory system
E.	**Variance Review**
1.	Review policy for variance between planned and actual activities
2.	Establishing parameters and guidelines for conducting these reviews
3.	Variance records and periodic review

Sixth Component: Material Management

No.	Questions
A.	**Parts & Material Availability**
1.	Periodic inventory review
2.	Documentation of material used on work order sheet.
3.	Spare parts availability
B.	**Storeroom Operation**
1.	Storeroom control procedure and record system
2.	Security and accessibility
3.	Stock Safety
4.	Integration of salvage and "bench stock" with inventory control
C.	**Inventory Functions and Costs**
1.	Purchase orders cost management
2.	Materials handling cost management
3.	Materials stock out cost management

CHAPTER IV

RESEARCH METHODOLOGY

4.0 INTRODUCTION

This chapter presents the research methodology, questionnaire design and population utilized to achieve the main objectives of the study. The first objective of reviewing current local and international practices of building maintenance management auditing and the second objective of identifying and assessment of affecting factors were achieved by a review of literature, interviews and pilot study. The result of this was the identification of factors listed in the developed distributed questionnaire to assess factors which should be considered for building maintenance management auditing. The third objective of reviewing factors affecting auditing of maintenance departments in large organizations in Saudi Arabia with their ranking was achieved by the survey conducted on governmental and private sectors.

The fourth objective of developing suitable maintenance auditing guidelines for organizations in Saudi Arabia was achieved by the results and data analysis. The result of this was the development of a auditing form for building maintenance management. Research methodology is summarized in Figure 4.1. (p.73)

4.1 IDENTIFICATION OF FACTORS AFFECTING MAINTENANCE AUDITING

The study on assessment of factors affecting maintenance management auditing in Saudi Arabia was conducted in two phases:

Phase I: Literature Review: In this phase factors affecting auditing of maintenance were identified from the literature on the subject such as books, journals and standards.

Phase II: Visits and interviews were conducted with maintenance managers, engineers and experts in large organizations in Saudi Arabia to get more ideas and concepts about the investigated factors.

4.2 QUESTIONNAIRE DESIGN

The questionnaire was designed in such a way to be simple and easy to understand by the respondents. The design of the questionnaire included open blocks for additions, changes or remarks by the respondents. It was formulated using references as mentioned in the Review of Literature (Chapters 2,3). The elements and components in the questionnaire developed by Applied Management Engineering, PC and Harvey H. Kaiser (1991) were used, with some additional elements from other resources (4,6,7,13,25).

The questionnaire was constructed in two parts:

Part I : General Information

This general information is to give an idea about the surveyed organization (Private sector/Public sector):

1. Organization Name
2. Respondent Name
3. Position
4. Experience
5. Primary function
6. Number of employees in the organization
7. Number of employees under respondent's supervision
8. Auditing of maintenance management
9. Frequency of maintenance management auditing
10. Type of auditors conducting the audit task

Part II : Technical Information

This section lists the main components and the factors which affect the maintenance management auditing and blank blocks were left for any changes or remarks by the respondents, (See Appendix B.)

4.2.1 SCORING

The first part of the questionnaire is about the organization itself, so no score was given on that part. In the second part, the importance of affecting factors on maintenance auditing, a score was assessed and considered. The following options were given in each question:

- Extremely Important = 4
- Important = 3
- Moderate = 2
- Little Important = 1
- Not Important = 0

4.3 POPULATION

The questionnaire was sent to the following sectors in the eastern province of Saudi Arabia:

A. Maintenance departments in large facilities of governmental sectors.

B. Private Sector companies that have maintenance departments to maintain their own large facilities, or classified as buildings maintenance contractors.

To obtain a statistical sample representation of the total population, the proposed equation was used, (34).

$$N = \frac{n}{(1 + n^1/N)} \qquad n^1 = \frac{S^2}{V^2}$$

where:

n = Sample size

N = Size of finite population,

n^1 = The value of organization distribution

S^2 = The maximum variance estimate.

This is estimated by

$S^2 = P(1 - P^1)$

P = The proportion of the population.
The maximum value is chosen as P = 0.5.

V = Standard deviation of the sampling distribution
V = 0.05 is a reasonable value.
Applying the above formula on the governmental organization of 50, the sample size will be

$$N^1 = \frac{(0.5)^2}{(0.05)^2} = 100 \quad \text{and } n = \frac{100}{1+100/50} = 33.33$$

Similarly when the formula is applied to the 50 private organizations, the minimum required sample n = 33.

$$\text{The minimum response rate} = \frac{33}{50} \times 100 = 66\%$$

However, the response rate for the government organizations was

$$\frac{(25)}{33} \times 100 = 75.76\%.$$

Also the actual response rate for the private organizations was

$$\frac{(22)}{33} \times 100 = 66.67\%,$$

which are reasonable sample sizes.

4.4 ANALYSIS METHODOLOGY

1. The average score for each factor was determined and importance index.

2. The data collected were analyzed utilizing statistical analysis systems (SAS) and results were presented in tables and graphs

3. Factors were ranked according to their higher importance index utilizing statistical analysis systems.

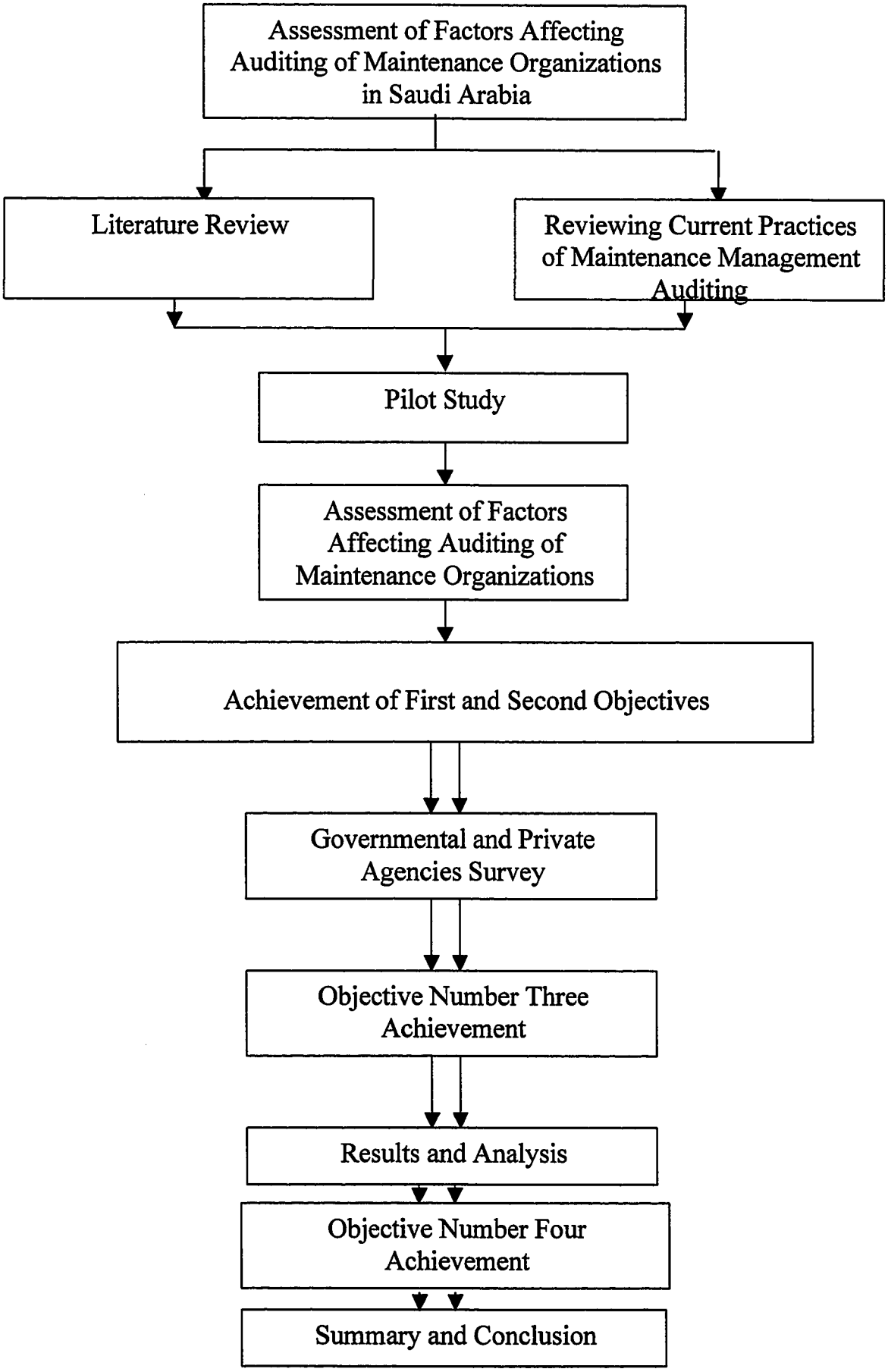

Fig. 4.1 – Research Methodology Flow Chart

CHAPTER V

ANALYSIS AND DISCUSSION OF THE RESULTS

5.0 INTRODUCTION

In this chapter analysis and results of the questionnaire survey are presented. The questionnaire was designed to get general information about respondents and their organizations and to assess the degree of importance of factors affecting building maintenance management in Saudi Arabia. The questionnaire was distributed to most of the known large organizations in the Eastern Province of Saudi Arabia. Personal visits and follow up to most of them were conducted to assure completion of the questionnaire.

5.1 MAIN COMPONENTS OF THE QUESTIONNAIRE ANALYSIS AND RESULTS

The results of this study were generated from responses received from maintenance departments in both public and private sectors. The structured data was summarized by calculating frequencies, means, standard deviations and ranks. The components of the questionnaire consist of the following:

Part One: General Information

1. Organization Name
2. Department Name
3. Respondent Name
4. Position of the respondent in the Organization

5. Years of experience of the respondent in maintenance management.
6. Nature of the organization (either private or governmental).
7. The main function of the organization
8. Number of employees in the organization
9. Number of employees in the maintenance department of the organization
10. Operation and maintenance work partially or completely contracted
11. Types of contracted operation and maintenance activities
12. Whether maintenance management is audited or not
13. Frequency of auditing if maintenance management is audited
14. Who normally performs the audit

Part Two: Technical Information

Factors affecting maintenance management auditing are categorized into six main components. Each component consists of a number of factors and sub-factors. These components are as follows:

1. Organization and human resources
2. Workload identification and performance measures
3. Work planning and scheduling
4. Work accomplishment
5. Information technology and appraisal
6. Material management

The complete questionnaire is shown in Appendix, B.

5.2 DATA ANALYSIS

5.2.1 PART ONE: GENERAL INFORMATION

The first part of the questionnaire consists of fourteen questions. The first three questions are optional. The remaining eleven questions are in a multiple choice format.

1. **Name of the Organization**

The respondents were given the option of writing the name of their organization. The survey indicated that fifteen out of forty-seven (31.9%) of the total respondents provided their organization's name, as shown in Fig. 5.1.

2. **Department Name**

The respondents were given the option of writing the name of their department. The survey indicated that eight respondents (32%) from the governmental sector mentioned their departmental names. On the other hand, seven respondents (31.8%) from the private sector mentioned their departmental names. It was noted that those who wrote their organizational names were the same people who mentioned their departmental names, as shown in Fig. 5.1.

3. **Respondent Name**

The respondents were also given the option of writing their names. It was noted from the meetings and from completed questionnaires that most of the respondents did not like to mention their names. Three respondents (12%) wrote their names from government organizations, while six (27.3%) of the

respondents from the private sector mentioned their names, as shown in Fig. 5.1.

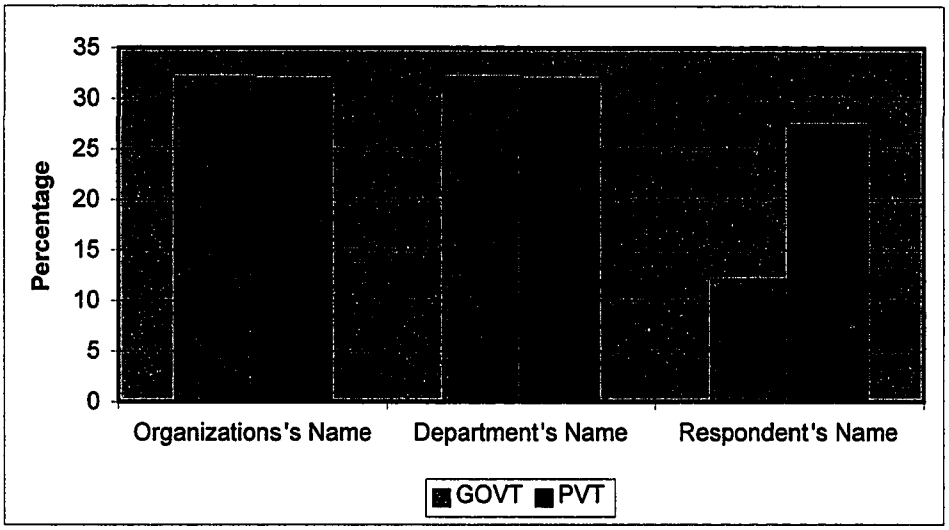

Fig. 5.1 – Mentioned Organizations, Departments & Respondents Names

4. **Position of the Respondent**

This question shows the position of each respondent in the maintenance department of the organization. The survey indicated that fifty-one (51%) of the respondents (24 out of 47) who attempted to answer the questionnaires were classified as engineers or architects. From these twenty-four respondents, fifteen (60%) were from the governmental sector and nine (40.9%) were from the private sector. Also, sixteen managers responded to the questionnaire or thirty-four percent (34%). Eight out of these sixteen managers (32%) were from the governmental sector while the other eight (36.4%) were from the private sector. Also, six supervisors responded to the questionnaires. Two (8%) of them were from the government sector, while

one respondent from the private sector held another position, as summarized in Fig. 5.2.

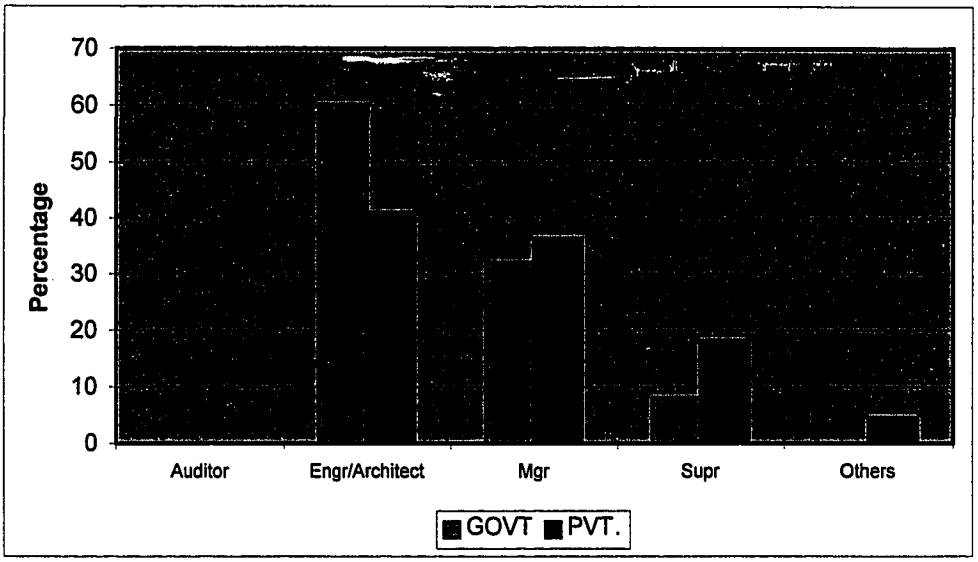

Fig. 5.2 – Positions of the Respondents

5. Years of Experience

The study considers the years of experience of the respondent in maintenance management in the organization. The years of experience were classified in this question into four categories, as follows: One to five years, six to ten years, eleven to fifteen years and more than fifteen years. It was found in the survey that twenty-three percent (23%) of the respondents (11 out of 47) had one to five years experience in maintenance work. Twenty six percent (26%) of respondents (12 out of 47) had six to ten years experience. Thirty-four percent (34%) (16 out of 47) of the respondents had eleven to fifteen years experience, and about seventeen percent (17%) (8 out of 47)

had more than fifteen years experience in maintenance work, as summarized in Fig. 5.3.

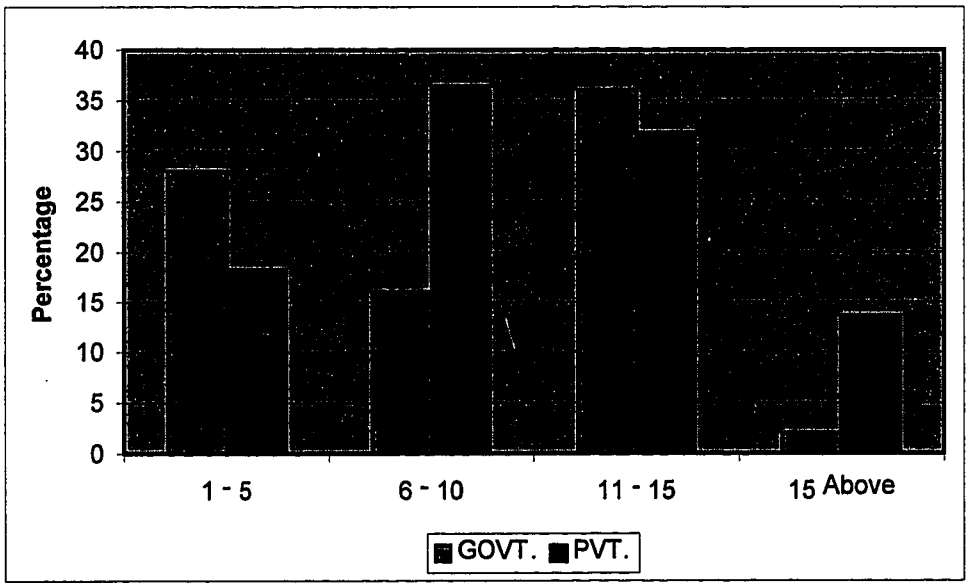

Fig. 5.3 – Years of Experience in Maintenance Work

6. Nature of the Organization

This question was provided to find out the nature of the organization of the respondent, whether it is government or private. The survey indicated that twenty-five out of forty-seven respondents (53.2%) were from the government sector, while the other twenty-two (46.8%) were from private organizations, as shown in Figure 5.4.

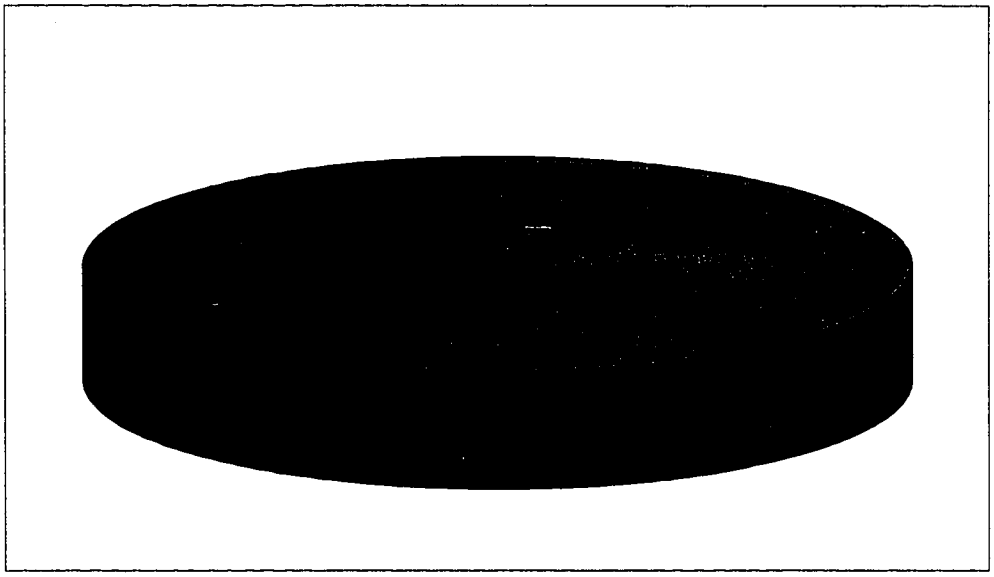

Figure 5.4 – Nature of Respondent's Organization

7. Main Function of the Organization

This question dealt with the function of the organization. Different organizations perform different types of maintenance work. The main functions were classified into commercial, industrial, healthcare, educational, and others to be specified by respondents. The survey indicated that twenty-eight percent (28%) of the respondents belonged to commercial organizations, seventeen percent (17%) were from industrial organizations, thirteen percent (13%) from healthcare organizations, the same (13%) from

educational organizations and the remaining thirty percent (30%) from other organizations, such as services organizations in most cases, as summarized in Fig. 5.5.

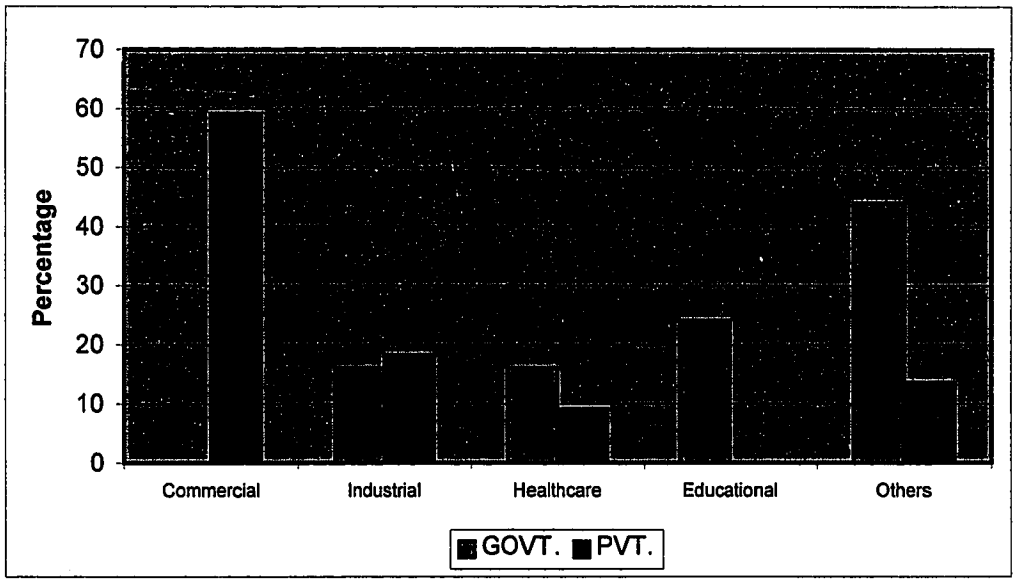

Fig. 5.5 – Main Function of the Organizations

8. The Number of Organization Personnel

This question provided the number of organization personnel. The number of employees in the organization reflects the volume of maintenance work in the organization. The survey indicated that seventeen percent (17%) of the respondents were from organizations having up to one hundred employees, eleven percent (11%) from organizations having between 101 – 200 employees, thirteen percent (13%) from organizations which have 201 – 300 employees, two percent (2%) from organizations having 301 – 400 employees, and another two percent (2%) from organizations in which there are 401 – 500 personnel, while twenty-six respondents (55.3%) were from

organizations having more than five hundred employees, as shown in Figure 5.6.

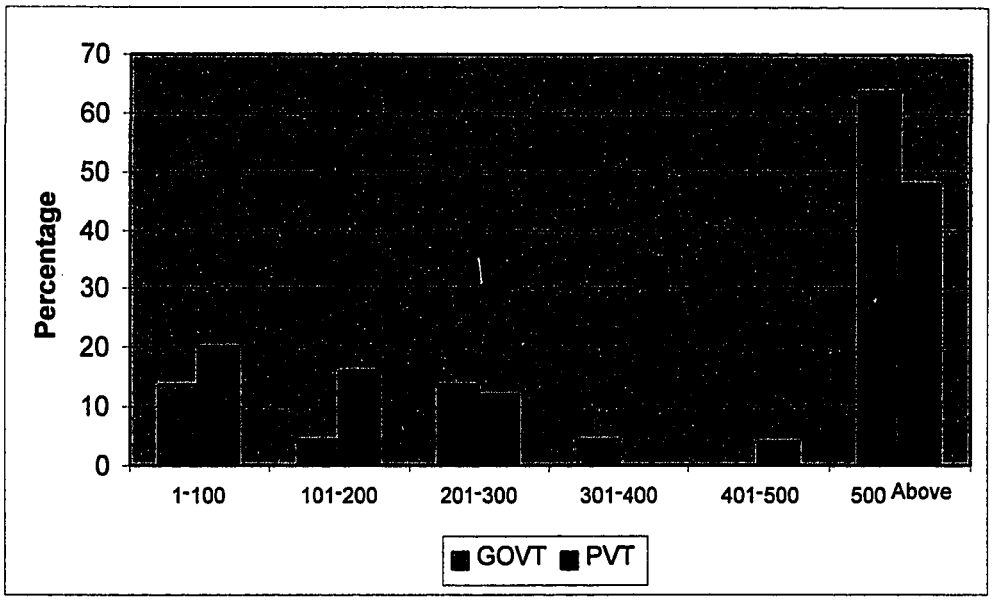

Fig. 5.6 – The Number of Organization Personnel

9. The Number of Maintenance Department Personnel

The number of maintenance department personnel is very important for this study. The number of maintenance employees reflects the volume of work performed by the maintenance department and by direct laborers in the maintenance department. The survey indicated that around four percent (4%) of the respondents have 11 – 20 employees in their maintenance departments. The same percent (4%) came from respondents having their 21 – 30 employees in their maintenance departments. Around eleven percent (11%) of the respondents had 41 – 50 employees. The majority of respondents (79.1%) have more than fifty employees in their maintenance departments. One respondent didn't indicate the number of personnel in the

maintenance department of his organization. The results are summarized in Figure 5.7.

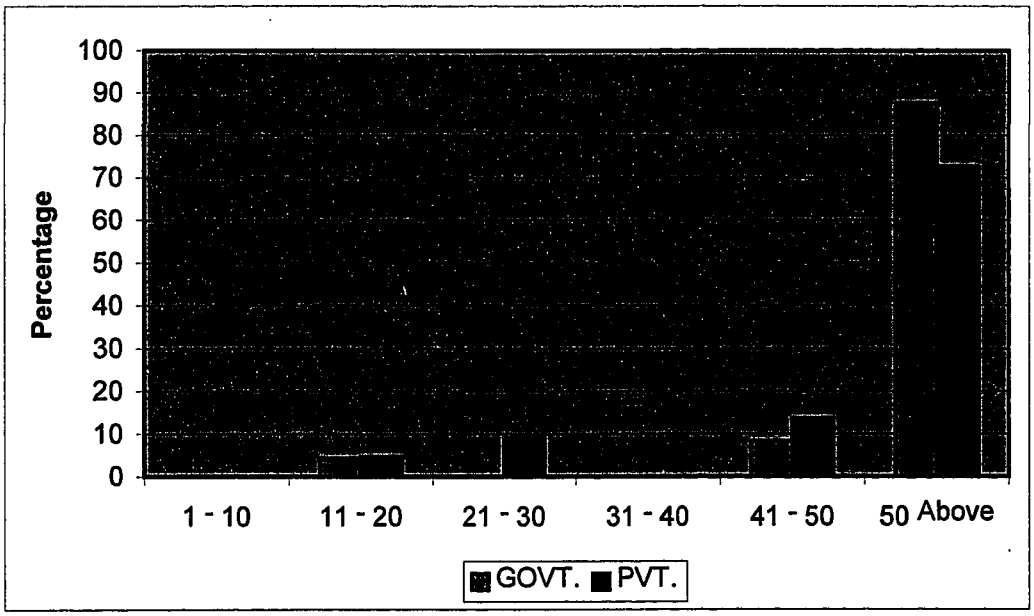

Fig. 5.7 – Number of Personnel in Maintenance Department

10. The Execution of Maintenance Work

In this question, forty-six respondents (24 respondents from government sector and 22 from private) indicated whether some or all maintenance work was contracted. It was found that eighty percent (80%) of the respondents indicated that operation and maintenance work was partially or completely contracted, as shown in Figure 5.8.

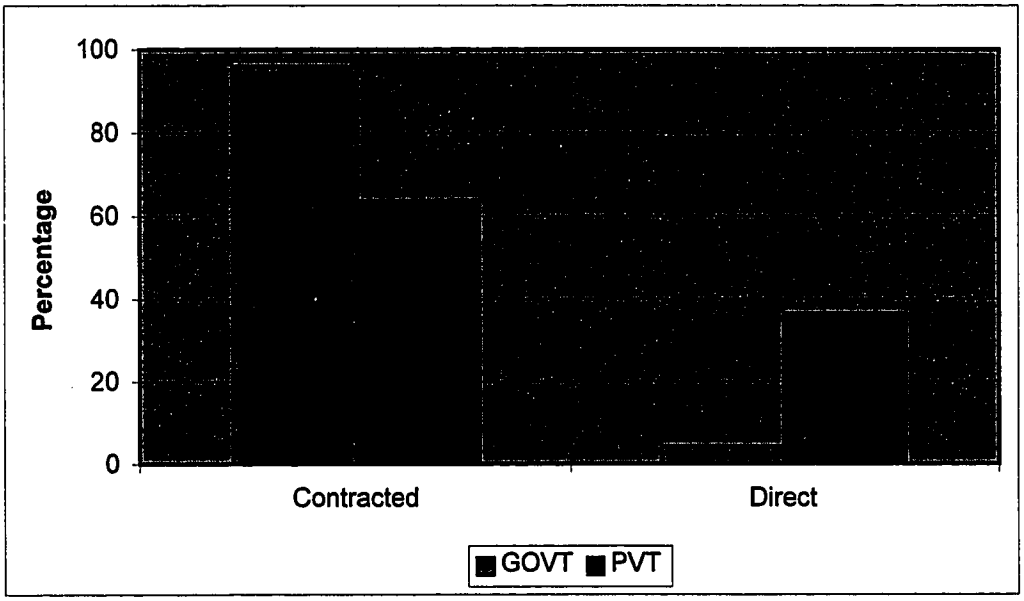

Fig. 5.8 – The Execution of Maintenance Work

11. Operation & Maintenance Contracted Activities

It was expected that some organizations would employ outside contractors to maintain their facilities, while others would contract some types of operations and maintenance, such as electrical, mechanical, and cleaning, and retain other work in-house. The survey indicated that around fifty-one (51%) of the respondents contracting all or some maintenance work conduct all operations and maintenance work through contractors, nineteen percent (19%) of respondents use contractors to repair and maintain major plants,

while the remaining 30% employ a combination of contracted and in-house operations and maintenance as follows:

- 2.1% of the respondents contract for maintaining horticultural work.
- 4.3% of the respondents contract for cleaning work.
- 4.3% of the respondents contract specialized equipment maintenance.
- 2% of the respondents employ contractors for other purposes.

It was also noticed that some maintenance departments do not conduct agricultural work while others are not responsible for cleaning work, as summarized in Fig. 5.9.

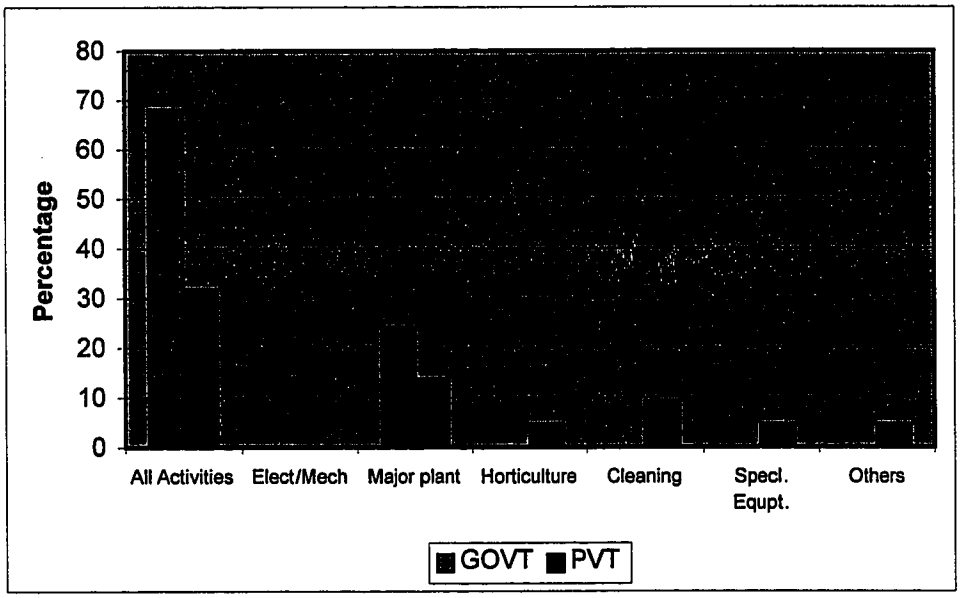

Fig. 5. 9 – Contracted Operation & Maintenance Activities

12. Maintenance Management Auditing

This question provided the information as to whether the maintenance management was audited. It was found that twenty nine (61.7%) of the total respondents audit their maintenance management. The survey indicated that twelve out of these twenty nine (41.4%) of the respondents conducting the auditing belong to government organizations, while the remaining (58.6%) are from private organizations. The results are summarized in Fig. 5.10.

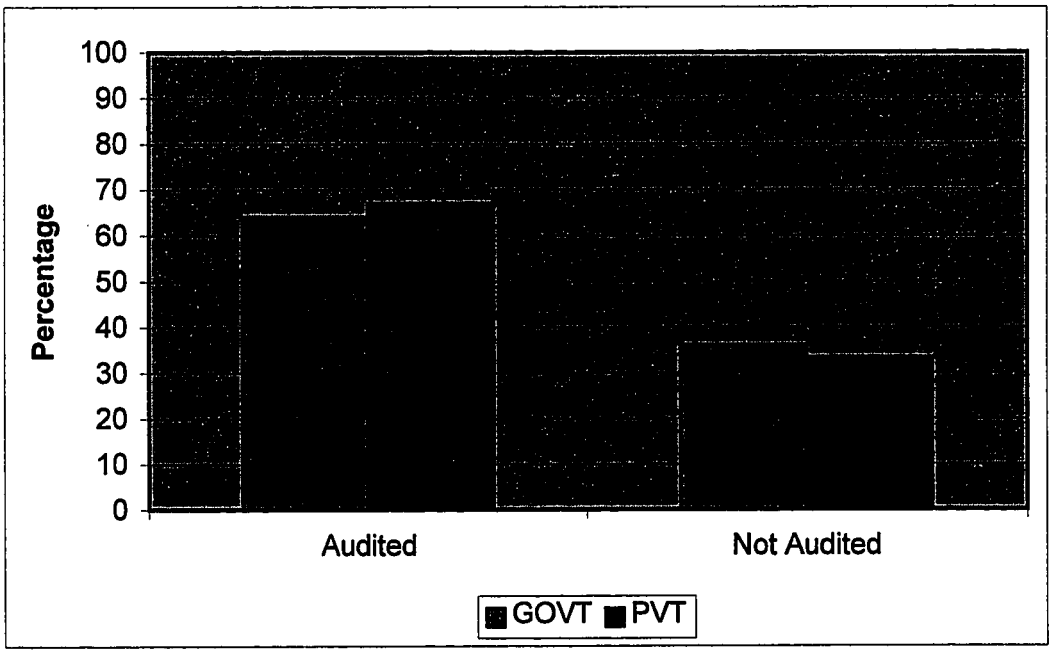

Fig. 5. 10 – Maintenance Management Auditing

13. Frequency of Maintenance Management Auditing

It is important to know the frequency of auditing in departments that conduct auditing. In the questionnaire, respondents were asked to select one of four categories: once a year, twice a year, more than twice a year, or others which should be specified by the respondents. It was found in this survey that twenty nine respondents (61.7%) conduct the auditing. Sixteen respondents

(55%) of these organizations conduct auditing once a year, four of them (13.8%) conduct auditing twice a year, three respondents (10.4%) audit their maintenance management more than two times per year, and six respondents (20.7%) do the auditing with another frequency, such as in urgent cases or in irregular frequencies as respondents mentioned. The resuls are summarized in Fig. 5.11.

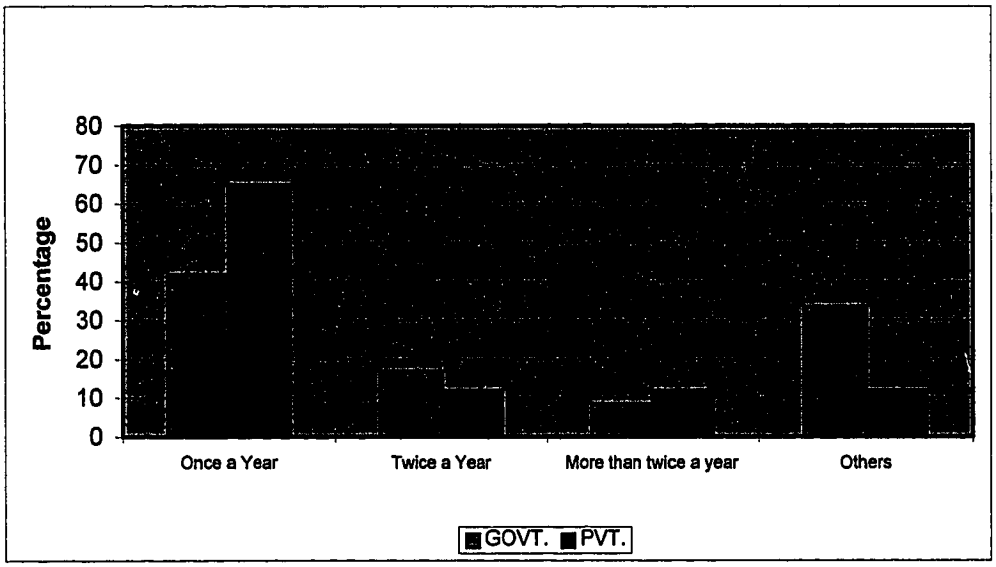

Fig. 5. 11 – Frequency of Auditing

14. Who Performs the Audit

From the literature review and from received answered questionnaires it was found that the audit can be conducted by internal auditors, external auditors, consultants, or a team of consultants with some internal auditors or expert managers from the same department. It was found that twenty nine out of forty-seven organizations conduct the auditing (12 Government, 17 Private sector). The survey indicated that most organizations conduct auditing through internal auditors, with the highest percentage (58.6%), followed by consultants (20.6%), then by external auditors (13.8%), while seven percent

(two respondents out of twenty nine) conduct the audit in other ways. In these two organizations the audit is done by their own engineers or a committee from both internal directors and external consultants, as shown in Fig. 5.12.

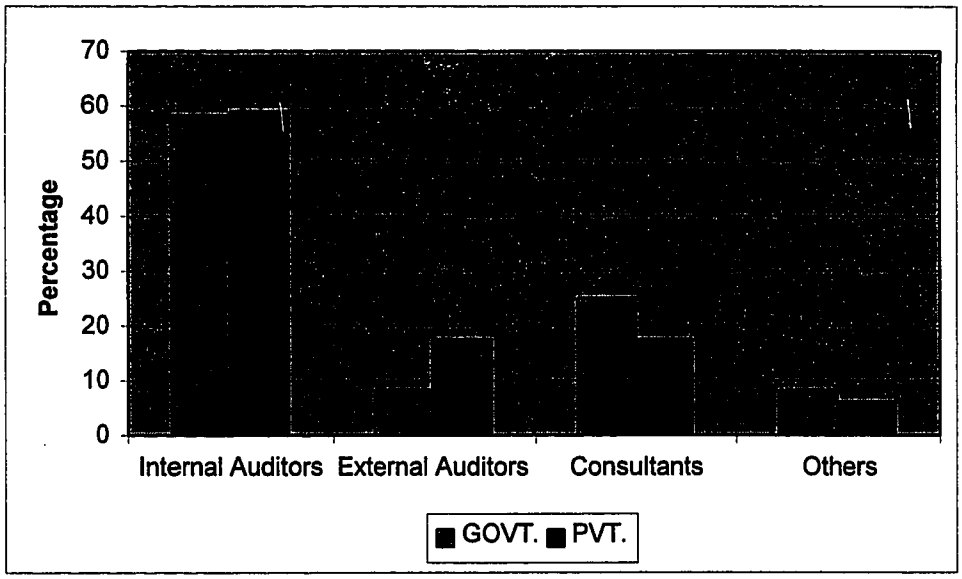

Fig. 5. 12 – Types of Auditors in Organizations Conducting Audit

5.2.2. PART TWO: FACTORS AFFECTING BUILDING MAINTENANCE MANAGEMENT AUDITING IN SAUDI ARABIA

The second part of the questionnaire consists of six major components which contain the factors and sub-factors that affect the auditing of building maintenance management in Saudi Arabia. These factors and sub-factors were given criterion values ranging from extremely important (4) to not important (0). The respondents were asked to choose the most appropriate answer that describes the view of maintenance management in his organization, as follows:

- Extremely Important (4)
- Important (3)

- Moderately Important (2)
- Little Important (1)
- Not Important (0)

Many approaches can be used to specify the mean ranges, but a similar approach to that of the KFUPM students' GPA scale was used in this research, as follows.

Excellent	3.5	≤	Average value	≤	4.0
Very good	2.75	≤	Average value	<	3.5
Good	1.75	≤	Average value	<	2.75
Pass	1.0	≤	Average value	<	1.75
Fail			Average value	<	1.0≤

The mean ranges were specified and an importance index was given to each criterion, as shown and explained in Table 5.1.

Table 5.1 – Mean Value and Importance Index Ranges

Scale Description	Mean Range	Importance Index (%)
Not Important	Less than 1.00	I.I. < 25
Little Important	1.00 – less than 1.75	25 ≤ I.I. < 43.75
Moderately Important	1.75 – less than 2.75	43.75 ≤ I.I. < 68.75
Important	2.75 – less than 3.5	68.75 ≤ I.I. < 87.5
Extremely Important	3.5 – 4.00	87.5 ≤ I.I. ≤ 100

4	3	2	1	0
Ext. Imp.	Important	Mod. Imp.	Not Very Imp	Not Imp.
3.5	2.75	1.75	0.99	

The above ranges were used to measure each variable. The importance indices were calculated for each variable using the following formula:

$$\text{The Importance Index (II)(\%)} = \frac{4(n_1) + 3(n_2) + 2(n_3) + 1(n_4) + 0(n_5)}{4(n_1 + n_2 + n_3 + n_4 + n_5)} \times 100$$

Factor affects building maintenance management system in the organization is:

- Extremely important : $87.5 \leq II < 100$
- Important : $68.75 \leq II < 87.5$
- Moderately Important : $43.75 \leq II < 68.75$
- Little Important : $25.0 \leq II < 43.75$
- Not Important $II < 25.0$

Main Components Ranking

The importance index for each component of factors affecting building maintenance management auditing was calculated and ranked with its importance index, as shown in Table 5.2.

Table 5.2 – Ranking of Major Components Affecting Auditing of Building Maintenance for Total Samples

Rank	Component	Importance Index	Ordinal Scale
1.	Organization & Human Resources	77.44	Important
2.	Material Management	74.31	Important
3.	Work Planning & Scheduling	73.84	Important
4.	Work Accomplishment	73.72	Important
5.	Information Technology and Appraisal	73.54	Important
6.	Work Load Identification and Performance Measures	72.93	Important

Details of importance indices and ranking for these six major components for each organization type is shown in Tables, 5.9-1 – 5.11-6.

Factor Ranking

The average mean value for each factor is calculated, then the 37 factors are ranked. Such factor as scored the highest importance index is ranked as No.1. The ranked factors affecting building maintenance management are summarized in Table 5.3. For the summary of each factor and sub-factor's mean and importance index value see Tables 5.5, 5.9, 5.12 and Appendix A.

5.2.3 RANK CORRELATION

To find the relationship among components and factors, a correlation coefficient (r) is used. A correlation coefficient equal to (-1) when there is a perfect negative relationship. On the other hand, variables with a perfect positive relationship have a correlation coefficient equal to (+1). Accordingly, the amount of correlation between two variables varies from (-1) to (+1). The Spearman correlation method (37) is used in this study.

The Spearman Correlation

To find and compare how two parties may agree, the Spearman Rank Correlation is used.

$$r = 1 - \frac{6 \Sigma d^2}{n (n^2-1)} \qquad (34,35)$$

where:

r = Rank correlation coefficient

d = difference between ranks on one variable and the other variable.

n = Number of cases

Ranking comparison and Spearman Rank Correlation is shown in Tables 5.4 – 5.6.

Example:

To find the agreement between governmental and private parties on ranking of factors:

$$r_{23} = \quad 1 - [\, 6 \times 2361 / (37 \times (37 - 1)^2 = 0.72$$

The Spearman Correlation Coefficients show the agreement between all three groups since all values of the Spearman Correlation Coefficient are positive. The agreement ranges from the high agreement to the lower one. The highest agreement is found between the total samples and private organizations. $r = 0.93$ and for 37 factors. Also, it is found that the second highest agreement is between the total samples and governmental organizations, where $r = 0.91$

The lowest agreement is between the governmental and private organizations where $r = 0.72$ for factors affecting building maintenance management auditing.

Test of Hypothesis for Factors

The "t" test is used to find the agreement between the total samples, the governmental and private organizations at confidence of 95%. The calculated value of 't' is compared with critical 't' value, as below:

1. The null hypothesis Ho : $r = 0$, Hn : $r = 0$
   The null hypothesis assumes that parties do not agree on the ranking.

2. The calculated value of 't':
   $t = [(n - 2) \times r^2 / (1 - r^2)]^{½}$ (34,35)

where :

r = the Spearman Correlation Coefficient

n = number of questions (number of factors in this study)

3. The critical value

From 't' distribution table, 't' value for n = 37 is 2.027 at confidence of 95%.

4. Decision

Comparing the critical 't' value from distribution table with calculated 't' values for the compared groups, it is found that the calculated 't' values are greater than critical 't' for all factors, as shown in Table 5.6, therefore the null hypothesis is rejected for ranking of factors affecting the auditing of maintenance management and all parties agree on the ranking.

Test of Hypothesis for Main Components

Since the governmental and private organizations agree on ranking factors affecting building maintenance management, the agreement includes ranking of major components of these factors, However, another test is conducted to assure the agreement, as shown in table 5.8.

In this test, the following formula is used:

$$t_c = \frac{\bar{X}_1 - \bar{X}_2}{SQRT\,[S_1^2/n_1 + S_2^2/n_2]} \qquad (35)$$

where:

$\bar{X}_1$ = The mean value of the first population

$\bar{X}_2$ = The mean value of the second population

S_1 = The standard deviation of the first sample

S_2 = The standard deviation of the second sample.

n_1 = Number of observations in the first sample

n_2 = Number of observations in the second sample.

The steps to test a hypothesis are the following:

1. State the null and alternate hypothesis.
2. A significance level specification.
3. A decision rule determination
4. Sample data obtaining, calculation of necessary statistics, and decision making.

In this case for $\alpha = 0.05$ at 95% confidence.

$$t_c = \frac{\bar{X}_1 - \bar{X}_1}{SQRT(S_1^2/m_1 + S_2^2/n_2)} \qquad (35)$$

t-table : $t_{0.05}$ = 1.96

It is found that all calculated 't' fall in the range $-2.016 \leq t \leq +2.016$ except t-value for the planning and scheduling component where tc = –2.18.

Decision:

The government and private organizations agree on the ranking of the main components of factors affecting building maintenance management except for the work planning and scheduling (tc = –2.18). Work planning and scheduling is given more consideration by private organizations because it affects directly their budgeting and finally the income which is main objective for these organizations. Achieving successful work planning and scheduling helps the private organization to achieve its mission and satisfy its customer requirements, consequently guarantees continuation of the business.

Table 5.3 - Summary of the Ranked Factors Affecting Building Maintenance Management (Total Samples)

Rank	Factor No	Question	Mean Value	Importance Index	Ordinal Scale
1	C2-B	Work Request Procedure	3.37	84.25	Important
2	C1-C	Work Control Center Functions, Staffing	3.28	82.00	Important
3	C6-A	Parts & Material Availability	3.27	81.75	Important
4	C1-A	Organization Structure	3.26	81.50	Important
5	C3-D	Budget Requirements for Maintenance & Repairs	3.2	80.00	Important
6	C2-C	Relationship Between Sections	3.16	79.00	Important
7	C1-B	Policies, Rules and Services	3.16	79.00	Important
8	C4-F	Supervisor Practices	3.15	78.75	Important
9	C2-A	Facility Condition Inspection	3.13	78.25	Important
10	C3-G	Emergency Works & Shutdown Scheduling	3.11	77.74	Important
11	C4-B	Craft and Material Availability	3.10	77.50	Important
12	C2-D	Preventive Maintenance (Equipment)	3.10	77.50	Important
13	C1-F	First Line Supervision & Responsibilities	3.10	77.50	Important
14	C3-E	Budget Execution Plan	3.10	77.44	Important
15	C5-D	Information System & Historical Records	3.09	77.25	Important
16	C6-B	Storeroom Operation	3.07	76.75	Important
17	C1-G	Training	3.06	76.50	Important
18	C1-D	Shop Organization	3.05	76.25	Important
19	C4-G	Use of Contracts	3.03	75.75	Important
20	C1-H	Motivation	2.96	74.00	Important
21	C5-C	Productivity Measurement	2.97	74.25	Important
22	C4-D	Shop, Spaces, Tools & Equipment	2.92	73.00	Important
23	C5-B	Measurement of Performance	2.95	73.75	Important
24	C5-A	Management Information System (MIS)	2.94	73.50	Important
25	C4-E	Transportation	2.91	72.75	Important
26	C2-G	Work Requirements Documentation	2.91	72.75	Important
27	C1-E	Shop Supervision & Planning Functions	2.84	71.00	Important
28	C3-A	Priority System	2.87	71.75	Important
29	C3-C	Alterations and Improvement Work	2.85	71.25	Important
30	C4-A	Shop Scheduling & Planning Functions	2.8	70.00	Important
31	C4-C	Maintenance Process Re-Engineering	2.82	70.50	Important

Table 5.3 (Contd) - Summary of the Ranked Factors Affecting Building Maintenance Management (Total Samples)

Rank	Factor No	Question	Mean Value	Importance Index	Ordinal Scale
32	C3-B	Work Classification and Weekly Schedule	2.76	69.00	Important
33	C3-F	Backlog of Funded Work	2.732	68.30	Moderately Important
34	C5-E	Variance Review	2.73	68.25	Moderately Important
35	C6-C	Inventory Functions and Costs	2.56	64.00	Moderately Important
36	C2-F	Routine, Recurring Work	2.44	61.00	Moderately Important
37	C2-E	Service work	2.31	57.75	Moderately Important
			2.97	74.36	

C1 = First Component C2 = Second Component C3 = Third Component
C4 = Fourth Component C5 = Fifth Component C6 = Sixth Component

Table 5.4 - Summary Table of the Ranked Factors Affecting the Audit

No.	Factor	(1) Total Samples Ranks	(2) Govt. Organizations Ranks	(3) Private Organizations Ranks
First Component: Organization & Human Resources				
1	Organization Structure	4	2	6
2	Policies, Rules and Services	7	6	10
3	Work Control Center Functions, Staffing	2	3	4
4	Shop Organization	18	8	25
5	Shop Supervision & Planning Function	27	29	30
6	First Line Supervision & Responsibilities	13	12	13
7	Training	17	19	12
8	Motivation	20	27	17
Second Factor: Work Load Identification & Performance Measures				
9	Facility Condition Inspection	9	5	14
10	Work Request Procedure	1	1	1
11	Relationship Between Sections	6	7	9
12	Preventive Maintenance (Equipment)	12	11	15
13	Service Work	37	37	37
14	Routine, Recurring Work	36	36	36
15	Work Requirements Documentation	26	31	21
Third Factor: Work Planning & Scheduling				
16	Priority System	28	17	33
17	Work Classification and Weekly Schedule	32	33	27
18	Alterations and Improvement Work	29	30	26
19	Budget Requirements for Maintenance and Repairs	5	10	3
20	Budget Execution Plan	14	20	8
21	Backlog of Funded Works	33	35	20
22	Emergency Work & Shutdown Scheduling	10	22	5
Fourth Factor: Work Accomplishment				
23	Shop Scheduling & Planning Procedure	29	32	29
24	Craft and Material Availability	11	9	16
25	Maintenance Process Re-Engineering	31	24	32
26	Shop, Spaces, Tools & Equipment	22	23	28

Table 5.4 - Summary Table of the Ranked Factors Affecting the Audit (Contd)

No.	Factor	(1) Total Samples Ranks	(2) Govt. Organizations Ranks	(3) Private Organizations Ranks
27	Transportation	25	15	31
28	Supervisory Practices	8	14	7
29	Use of Contracts	19	16	23
Fift Factor: Information Technology & Appraisal				
30	Management Information System (MIS)	24	25	22
31	Measurements of Performance	23	26	19
32	Productivity Measurement	21	21	24
33	Information System & Historical Records	15	18	11
34	Variance Review	34	29	34
Sixth Factor: Material Managemnt				
35	Parts & Material Availability	3	4	2
36	Storeroom Operation	16	13	18
37	Inventory Functions and Costs	35	34	35

Table 5.5 - Ranking Comparison Table of Factors Affecting Building Maintenance Management Auditing

1 Vs. 2	D12 x D12	1Vs. 3	D12 x D13	2 Vs. 3	D23 x D23
2	4	-2	4	-4	16
1	1	-3	9	-4	16
-1	1	-2	4	-1	1
10	100	-7	49	-17	289
-2	4	-3	9	-1	1
1	1	0	0	-1	1
-2	4	5	25	7	49
-7	49	3	9	10	100
4	16	-5	25	-9	81
0	0	0	0	0	0
-1	1	-3	9	-2	4
1	1	-3	9	-4	16
0	0	0	0	0	0
0	0	0	0	0	0
-5	25	5	25	10	100
11	121	-5	25	-16	256
-1	1	5	25	6	36
-1	1	3	9	4	16
-5	25	2	4	7	49
-6	36	6	36	12	144
-2	4	13	169	15	225
-12	144	5	25	17	289
-3	9	0	0	3	9
2	4	-5	25	-7	49
7	49	-1	1	-8	64
-1	1	-6	36	-5	25
10	100	-6	36	-16	256
-6	36	1	1	7	49
3	9	-4	16	-7	49
-1	1	2	4	3	9
-3	9	4	16	7	49
0	0	-3	9	-3	9
-3	9	4	16	7	49
5	25	0	0	-5	25
-1	1	1	1	2	4
3	9	-2	4	-5	25
1	1	0	0	-1	1
xls\rank-comparison	**802**		**635**		**2361**

Table 5.6 – Spearman Rank Correlation Major Components

Groups Compared	N	Sum (SQR (D))	N (N x N-1)	Spearman Rank Correlation Coefficient (r)	t – Value for testing Ho
1 VS 2	37	802	50616	0.91	13.1
1 VS 3	37	635	50616	0.93	14.9
2 VS 3	37	2361	50616	0.72	8.0

Table 5.7 - Ranking Summary Table of Major Components

No.	Component	Total Samples (1)	Govt. Organizations (2)	Private Companies (2)
1.	Organization & human resources	1	1	1
2.	Work Load identification & performance measures	6	5	5
3.	Work planning and scheduling	3	6	2
4.	Work accomplishment	4	2	6
5.	Information technology and appraisal	5	4	3
6.	Material management	2	3	4

Table 5.8 - t – Test of Hypothesis (for main components)

No	Component	Govt.		Pvt.		tc	$T_{0.5}$	Agreement Between GOVT & PVT Organizations
		Mean	S	Mean	S			
1	Organization & Human Resources	2.93	0.83	3.28	0.72	-1.55	±2.016	Agree
2	Workload Identification	2.82	0.82	3.11	0.72	-1.29	±2.016	Agree
3	Work Planning & Scheduling	2.71	0.90	3.23	0.73	-2.18	±2.016	Do not agree
4	Work Accomplishment	2.89	0.93	3.11	0.70	-1.17	±2.016	Agree
5	Information Technology & Appraisal	2.76	0.84	3.15	0.66	-1.78	±2.016	Agree
6	Material Management	2.74	1.0	3.14	0.74	-1.57	±2.016	Agree

5.3 MAJOR FINDINGS

As discussed in previous chapters the factors affecting building maintenance management auditing are categorized into six major components, each component composed of several factors and sub-factors. No other factors were revealed by the respondents, except for some suggestions that the work control office should report directly to higher authority in maintenance management; also, routine, recurring and service works should be considered as one factor. The following is a discussion of major findings obtained from the analysis of collected data, following the organization of components and their factors presented in Chapter Three and Questionnaire.

First Component: Organization and Human Resources

Organization and Human Resources is ranked as the first component affecting the auditing. It is considered to be "Important" by both government and private sector. This component is the highest because organization and human resources affect all other factors. Thus is ranked as the first due to the high importance of its factors and sub-factors as detailed below:

I-A Organization Structure

This factor is considered to be important by both sectors. Its average score is 81.5%. The high rank of this factor reflects the importance of organization structure in maintenance departments. A job description for each position sub-factor is considered to be extremely important by the government sector. On the other hand, the private sector respondents see that availability of an organization chart as the most important factor.

I-B Policies, Rules and Services

The policies, rules and services factor is considered to be "Important" by both government and private organizations. The score is 79%. This factor consists of three sub-factors: availability of general policies and objectives documentation, services clearly defined, and availability of active updating procedure. The government and private organizations consider all of the three sub-factors to be important.

I-C Work Control Center Functions, Staffing

This factor is ranked as the second highest important factor (82%). Its sub-factors are considered as important, except that clear work control and planning staff efficiency responsibilities were considered to be "Extremely Important" by the private sector. This factor is important because the work control center is the heart of the maintenance department. It should be highly organized and qualified personnel should be recruited for this center.

I-D Shop Organization

The shop organization factor and its sub-factors are ranked as "Important" by both sectors, except that availability of documented shop functions were considered as "Extremely Important" by the private sector. It was found that this factor's score was very high in the "Important" range. The importance index given is 78% by both sectors.

I-E Shop Supervision & Planning Functions

Both groups considered shop supervision and planning functions as "Important". All three sub-factors are considered as "Important" by both groups. Supervision of workshops is reflected in the productivity of the workshops. It is recommended that supervisors of workshops should

have satisfactory experience and qualifications to lead the production personnel in the department.

I-F First Line Supervision & Responsibilities

This factor is ranked as important in the total samples. Its Importance Index is 77.5%. Both the government and private sector considered this factor and all of its three sub-factors as "Important". It was noticed that the private sector gives more attention to first line supervision and responsibilities (I.I. = 82.2%) because first line supervisors and managers affect the productivity and the income of the organization. The centralization in some departments minimizes the importance of first line supervision.

I-G Training

Training is ranked as "Important" in the total samples (I.I. = 76.50%). This factor and its components are considered as "Important" by the government group, while technical training is considered as "Extremely Important" by the private organizations. It is noticed that the private sector gives more attention to training to improve the performance of their personnel, which will be reflected positively in the organization's income. Also, the more training the personnel get, the more motivation they will have.

I-H Motivation

Motivation is ranked as an "important" factor, its importance index is 74%, while the government organizations considered this factor as "moderately important" (I.I. = 67.93%). Also, the government organizations considered the sub-factors as "moderately important" except that financial motivations, awards and recognition were considered

as "important". The private sector considered all sub-factors as "important". The justification for this difference is that motivatation affects directly the productivity of the laborers and eventually the organization's income.

Second Component: Work Load Identification & Performance Measures

This component consists of a number of factors and sub-factors related to the identification of work load in a maintenance department and the way in which the management plans the procedure of conducting work and selects parameters to measure the performance. This component is ranked as No. 6 (I.I. = 72.93%)in the total samples: it is considered as "Important". The gathered results indicated that the importance index (I.I) was 68.61% and 77.82% by government and private sectors respectively. The component consists of seven factors as detailed below:

II-A Facility Condition Inspection

The results indicated that this factor is ranked as "Important" in the total samples (I.I. = 78.25%). Both the government and private organizations considered this factor and its sub-factors to be "Important". The difference in the importance indices of sub-factors between the two groups is due to the attention given by the private sector to facilities inspection and keeping facilities in a better condition to increase the facility's continuation in service. Facility condition also affects advertising and competition among commercial organizations such as malls and hotels.

II-B Work Request Procedure

The importance index of this factor is ranked as 85.25% in the total samples and considered as "Important" by both groups. All three sub-factors comprising the work request procedure factor are considered as "Important", except that the availability of a work order system is considered as "Extremely Important" in the total samples. The government organizations considered this factor and all three sub-factors as "Important", while the private sector considered all of them as "Extremely Important" except that information feedback to the requester was considered as "Important".

II-C Relationship Between Sections

The factor "relationship between sections" and its sub-factors are considered to be "Important". It was given Importance Index values of (I.I. = 75%) and (I.I. = 83.71%) by government and private sectors respectively. The relationships between sections should be clear and understood by employees in different sections. Some jobs require that many sections work together as one team at the same time, while others are conducted by one section after others.

II-D Preventive Maintenance (Equipment)

This factor and its sub-factors are ranked as "Extremely Important". It consists of three sub-factors, which are considered as "Important" by both sectors except that planned preventive maintenance is considered as "Extremely Important" by private organizations. The planning of preventive maintenance is "Extremely Important" for the private sector because it directly affects the convenience of their customers.

II-E Service Work

Service work is considered as "Moderately Important" by both groups (I.I. = 57.75%). Its sub-factors are considered as "Moderately Important" by both government and private sectors. In many organizations service work is not classified separately from maintenance work. The perception of documenting service work procedures and conducting work load analysis should be considered by maintenance management.

II-F Routine, Recurring Work

This factor of routine and recurring work is considered as "Moderately Important" (I.I. = 61%). It is noticed that no attention is paid to classifying maintenance work as routine and recurring to be controlled separately. However, no respondent considered this factor as "Not Important". It is suggested that maintenance personnel's perception of this factor should be increased to lead them to a proper distribution of their work and give them a suitable priority and scheduling. It is also suggested by some respondents that this factor and the previous one are considered as one factor (service, routine and recurring work).

II-G Work Requirements Documentation

This factor is ranked as "Important" (I.I. = 72.75%). From the interviews it is found that while the importance of documentation is perceived practically no attention and consideration are given to this point. In some private sector companies some documentation is available for accounting auditing purposes. However, it was mentioned by some respondents and felt during visits and interviews that this factor has started to be considered, due to the increase in perception of the importance of maintenance, and the availability of software helps in this regard.

III. Third Component: Work Planning & Scheduling

This component is ranked as the third component affecting the auditing of maintenance management. It is considered as "Important": the Importance Index is 73.84%. Planning and scheduling are necessary for maintenance management to perform its mission in a professional way. This component helps the management to estimate the needed funds and budget. Also the scheduling of work helps the management to follow up the productivity and assess the performance of the department. Scheduling also guarantees better services and continuity of the operation of the facility. It was noticed that this component is given more consideration by private sector (I.I = 78%) while it is given I.I = 67.8% by the government sector. The following are factors composing this component:

III-A Priority System

Priority system is ranked as "Important" and its Importance Index is 71.75%. The documentation and distribution of priority criteria is considered as "Important" by government organizations whereas the private sector considered this sub-factor as "Moderately Important".

III-B Work Classification and Weekly Schedule

This factor is considered as "Important" (I.I. = 69%) in the total samples. The work classification and weekly schedule can be identified as the classification of all tasks, developing work processing procedures and weekly scheduling for conducting work. These factors and their sub-factors are considered as "Moderately Important" by government organizations, whereas they are considered as "Important" by private organizations.

III-C Alterations and Improvement Work

This factor is ranked as "Important" in the total samples (I.I. = 71.25%). Although this work should be processed and programmed separately from maintenance work, some organizations utilize their maintenance workforce to conduct major alterations and modifications which consume a lot of time and material, affecting maintenance work badly.

III-D Budget Requirements for Maintenance & Repairs

This factor is considered as "Important". The cumulative Importance Index is 80%. It includes planning an annual maintenance budget, cost reporting, and documentation for renewals and replacements. Government and private organizations ranked these parameters as "Important", except that the private sector group ranked planning annual maintenance budgets as "Extremely Important". This reflects the importance of financial support to maintenance departments. The budget given to a maintenance department will be reflected in its performance in retaining the facility in a satisfactory condition. It is clear that the greater the budget given to maintain commercial buildings, the more convenience to customers and finally a better income will be received from this investment.

III-E Budget Execution Plan

This major factor is ranked as "Important": its I.I. = 77.44%. The execution plan of a budget is as important as preparing the budget requirement. It is clear that the private sector looks to financial expenditure more carefully. It means for the private sector the company's continued existence or leaving the business. Government budgets usually are spent based on studied previous preparations and attached with

explanations and items to be spent on. However, planning is necessary for execution with priorities to maximize the benefit.

III-F Backlog of Funded Work

Backlog of funded work is considered to be "Moderately important" in the total samples (I.I. = 68.3%). It is important that the backlog summaries of approved work are reported, reviewed and analyzed. The backlog of funded work helps maintenance management to evaluate productivity.

III-G Emergency Work & Shutdown Scheduling

Emergency work and shutdown scheduling is considered as "Important" (I.I. 77.74%). The private organizations considered minimization of emergency occurance and shutdown planning as "Extremely Important". Shutdown scheduling minimizes emergency work which causes disturbance of continuity of works. Sometimes emergency shutdown causes serious problems, such as in hospitals, factories and commercial buildings. Some respondents suggested that long term plans (which is a sub-factor) should not be included in this factor. However, long term plans are important even for shutdown scheduling, such as in air conditioning stations and mechanical works.

IV. Fourth Component: Work Accomplishment

The accomplishment of a task can be done in many pictures. The method of accomplishment and time consumed to complete the work reflect how systematic and professional is the system in the department. This component indicates how skilled is the manpower in the department. It is ranked as No. 4 in the total components of factors affecting building

maintenance management auditing, (I.I = 70.83%) and considered as "Important". The factors comprising this component are as follows:

IV-A Shop Scheduling & Planning Procedure

This factor is ranked as "Important", (the cumulative I.I. = 70%). Government and private sector groups agreed that this factor and its sub-factors are considered as "Important", except that the government group tend to evaluate the shop planning and documentation sub-factor as "Moderately Important".

IV-B Craft and Material Availability

The necessity of availability of manpower and material to the accomplishment of work is reflected by consideration of this factor as "Important", (I.I. = 77.5%). Planning of craft distribution for the shop workforce, scheduling for craft hours, material scheduling for individual work orders, and equipment availability determine how this factor is effective in evaluation of the system. All sub-factors are considered as "Important", except work scheduling for craft hours is considered as "Moderately Important" by government organizations.

IV-C Maintenance Re-Engineering

The profession of maintenance requires the application of maintenance process re-engineering. This factor is considered as "Important", (I.I. = 70.5%). There is agreement between both groups covered in the survey that this component is "Important". It is noted from interviews and meetings with many maintenance staff that there is a need for key maintenance processes, automation of the work process, and establishment of performance indicators. However, many of them prefer to continue on their routine process which is inefficient.

IV-D Shop Spaces, Tools and Equipment

The importance index of this factor related to shop spaces, tools and equipment is 73% and considered as "Important". Government and private sector groups agreed that adequate shop space, tools and equipment and maintaining shop conditions are important, except that shop space adequacy is considered to be "Moderately Important" by the government sector.

IV-E Transportation

This major factor is considered as "Important" in the total samples, I.I = 72.75%. It is necessary for maintenance departments to have an adequate number of vehicles, especially for those departments servicing and maintaining large organizations such as compounds, cities, etc. The vehicles should be well maintained and provided with necessary tools. Some respondents indicated that productivity of laborers is reduced because of inadequate transportation in their organizations.

IV-F Supervisory Practices

This major factor directly affects the productivity and performance of maintenance departments. The total samples considered supervisory practices as an "Important" factor (I.I. = 78.75%). The surveyed respondents indicated the importance of time spent by supervisors on direct supervision. However, a number of supervisors complain that they have no clear responsibilities, no authority given to them to improve their workshops and sections, and no incentives to encourage them to be more professional.

IV-G Use of Contracts

All respondents agreed that the use of contracts is an "Important" issue (I.I. = 75.75%). The higher level management is concerned more about this factor. Balancing between contracts and in-house staff is an important issue for a decision maker. Each one of the choices has advantages and disadvantages

V. Fifth Component: Information Technology & Appraisal

This factor is ranked as No. 5 in the total six components affecting the auditing of building maintenance management. It is considered as "Important" (I.I. = 73.51%). Information Technology can be utilized to improve performance, automate procedures and audit the maintenance management systems. Software and hardware help to make facilities more efficient and organized. This concept is understood by most of the respondents, however a number of them reported dissatisfaction with their implementation of this major factor. The details of five sub-factors of information technology and appraisal are as follows:

VI-A Management Information System (MIS)

This factor is considered as "Important" on average in the total samples, I.I. = 73.5%. The government sector considered this factor and its sub-factors as "Important" and "Moderately Important" while the private sector group considered Management Information System and its sub-factors as "Important"

VI-B Performance Measurement

This factor is considered as "Important" in the average of the total samples (I.I. = 73.75%). The private sector group considers this factor and its sub-factors as "Important". Performance measurement methods

and using equipment performance standards are considered as "Moderately Important" by government organizations.

V-C Productivity Measurement

This factor is ranked as an "Important" factor (I.I. = 74.25%). Both sectors agree that this factor and all of its comprising sub-factors are "Important".

V-D Information System and Historical Records

Information system and historical records is ranked as an "Important" factor (I.I. = 77.25%). The respondents from both government and private sectors agree that all sub-factors are important. However, higher mean values are given by respondents from private organizations to this factor and its sub-factors.

V-E Variance Review

Variance review is considered as "Moderately Important" in the cumulative work (I.I. = 68.25%). There is no big difference between the two respondent groups in ranking this factor and its sub-factors. There should be a review policy for variance review between planned and actual activities.

VI. Sixth Component: Material Management

This component is ranked as the second among the six components. It is considered as "Important", the mean value is 3.00 (I.I. = 75.06%). Every maintenance department depends on manpower and material to achieve its mission. Without proper material management, management can't build a good system. Also from the financial point of view, the cost of material consumption is more than manpower wages in some workshops.

This component is related to the availability of parts and material, storeroom operation, inventory functions and costs. The material management sub-factors are ranked as detailed below:

VI-A Parts and Material Availability

This factor is considered as "Extremely Important". The average mean value is 3.30 (I.I 82.5%). Its sub-factors are considered as "Extremely Important" by both groups, except that inventory periodic review is ranked as "Important" by the government sector.

VI-B Storeroom Operation

This factor is ranked as "Extremely Important" by the average of total samples, average mean value is 3.30 (I.I. = 82.50%). However, the respondents from the government sector considered this factor and its sub-factors as "Important". The private sector group agree also that integration of salvage and bench stock with the inventory control sub-factor is considered as "Important". But in the average, except for this sub-factor, all others are ranked as "Extremely Important".

VI-C Inventory Functions and Costs

The inventory functions and costs factor and its sub-factors are considered as "Important" by both groups. The average mean value is 2.68 (I.I 67.0%). It is noticed that material management and inventory functions are handled by other departments than the maintenance department. This point has advantages and disadvantages and should be studied in detail as other study. Also maintenance departments in some organizations are not involved directly in purchase orders and cost management. This point also can be discussed and studied in more detail in further studies.

Tables 5.9-1 – 5.11-6 present the details of all the statistics resulting from the data received from the questionnaires. More details are also shown in Appendix A.

Table 5.9-1 - Ranking Summary Table for Government Sector Samples
First Component : Organization & Human Resources

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	A3	Job description for each position	3.42	85.50	Important
2	C1	Clear work control responsibilities	3.20	80.00	Important
3	C2	Effectiveness evaluation and review	3.16	79.00	Important
4	D2	Clear related crafts relationships	3.12	78.00	Important
5	C	Work control center functions, staffing	3.12	78.00	Important
6	A	Organization structure	3.12	78.00	Important
7	C5	Establishing of data analysis for management use	3.08	77.00	Important
8	C4	Planning staff sufficiency	3.08	77.00	Important
9	C3	Work reception staff training	3.08	77.00	Important
10	B2	Complete services organization clearly defined	3.08	77.00	Important
11	B1	Availability of general policies and objectives document	3.08	77.00	Important
12	A4	Data updating procedure	3.04	76.00	Important
13	A1	Availability of organization chart	3.04	76.00	Important
14	G1	Technical training	3.00	75.00	Important
15	F3	Labor productivity follow up	3.00	75.00	Important
16	F1	Ratio of supervisors to craft workers	3.00	75.00	Important
17	B	Policies, Rules and Services	3.00	75.00	Important
18	A2	Availability of functioning statement for all components which define roles, authority & responsibility	3.00		
19	D	Shop organization	2.97	74.25	Important
20	H4	Employees awards and recognition	2.96	74.00	Important
21	F	Firstline supervision & responsibilities	2.93	73.25	Important
22	D1	Availability of documented shop functions	2.92	73.00	Important
23	D3	Effectiveness review and evaluation	2.88	72.00	Important
24	G	Trainig	2.86	71.50	Important
25	B3	Availability of active updating procedure	2.84	71.00	Important
26	G3	Management training	2.83	70.75	Important
27	H3	Employees financial motivation	2.80	70.00	Important
28	F2	Availability of adequate support staff	2.80	70.00	Important
29	E1	Multi-craft job coordination	2.80	70.00	Important
30	E2	Supervision coverage adequacy	2.79	69.75	Important
31	G2	Productivity training	2.76	69.00	Important
32	H5	Less barriers between labor and management	2.72	68.00	Moderately Important
33	H	Motivation	2.72	68.00	Moderately Important
34	E	Shop supervision & planning functions	2.68	67.00	Moderately Important
35	H1	Conducting a climate survey	2.67	66.75	Moderately Important
36	H2	Annual turnover due to quits & discharges of labors	2.44	61.00	Moderately Important
37	E3	Establishment of planning functions to support	2.44	61.00	Moderately Important
		shop supervisors.			
		Total		**2635.75**	
		Average Score		**71.24**	

Table 5.9-2 - Ranking Summary Table for Government Sector Samples
Second Component : Work Load Identification & Performance Measures

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	B1	Availability of work order system	3.48	87.00	Important
2	B	Work Request Procedure	3.17	79.25	Important
3	C1	Personnel understanding of their work relationships	3.12	78.00	Important
4	A1	Availability of inspection scheduling	3.04	76.00	Important
5	B2	Availability of documented procedure	3.04	76.00	Important
6	D1	Planned preventive maintenance	3.04	76.00	Important
7	A	Facility Condition Inspection	3.01	75.25	Important
8	C	Relationship Between Sections	3.00	75.00	Important
9	A2	Availability of documented inspection scheduling	3.00	75.00	Important
10	A3	Conducting maint. & repairs based on inspection	3.00	75.00	Important
11	B3	Information feedback to requester	3.00	75.00	Important
12	C2	Job description of each section	3.00	75.00	Important
13	G1	Establishing prioritization of all works	2.96	74.00	Important
14	D	Preventive Maintenance (Equipment)	2.95	73.75	Important
15	D2	Accomplishing preventive maint. work within 10% of schedule	2.92	72.92	Important
16	C3	Team work assignment for the same jobs	2.88	72.00	Important
17	D3	Periodically reviewing equipment history records	2.88	72.00	Important
18	G	Work Requirements Documentation	2.65	66.25	Moderately Important
19	G2	Summarizing works by status	2.64	66.00	Moderately Important
20	E1	Classify service works separately from other works	2.36	59.00	Moderately Important
21	G3	Reviewing work load periodically	2.36	59.00	Moderately Important
22	F2	Reporting standing workorder scheduling & performance weekly.	2.32	58.00	Moderately Important
23	F3	Cost estimation of recurring work	2.32	58.00	Moderately Important
24	F	Routine, Recurring Work	2.27	56.75	Moderately Important
25	E	Service Work.	2.16	54.00	Moderately Important
26	E2	Clearly documenting processing procedure of service works.	2.16	54.00	Moderately Important
27	F1	Classify recurring work to be controlled separately.	2.16	54.00	Moderately Important
28	E3	Conducting work load analysis.	1.96	49.00	Moderately Important
		Total		**1921.17**	
		Average Score		**68.61**	

Table 5.9-3 - Ranking Summary Table for Government Sector Samples
Third Component : Work Planning & Scheduling

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	G1	Minimizing emergency work occurrence	3.12	78.00	Important
2	D1	Planning annual maintenance budget	3.00	75.00	Important
3	D	Budget Requirements for Maintenance and Repairs	2.96	74.00	Important
4	D3	Formally idnetifying and presenting long range requirements for renewals and replacement to financial managers.	2.96	74.00	Important
5	E2	Identifying works in the budget plan	2.96	74.00	Important
6	D2	Cost reporting & budget documentation	2.92	73.00	Important
7	G2	Standard time assessment of specific works	2.92	73.00	Important
8	A2	Appropriateness of priority criteria	2.92	72.92	Important
9	A	Priority System	2.88	72.00	Important
10	A1	Documentation & distribution of priority criteria	2.88	72.00	Important
11	E	Budget Execution Plan	2.84	71.00	Important
12	A3	Consistency of priority criteria	2.84	71.00	Important
13	G	Emergency works & shutdown scheduling	2.81	70.25	Important
14	E1	Establishing periodic budget execution planning	2.80	70.00	Important
15	E3	Controlling budget against plans	2.76	69.00	Important
16	C1	Classifying alterations & improvement separately from maintenance works.	2.68	67.00	Moderately Important
17	C3	Distribution of work force within a planned taget	2.68	67.00	Moderately Important
18	G3	Shutdown scheduling and planning	2.68	67.00	Moderately Important
19	C	Alterations and Improvement Work	2.65	66.25	
20	C2	Processing & programming of work separately from maintenance.	2.60	65.00	Moderately Important
21	B1	Work classification for all tasks.	2.56	64.00	Moderately Important
22	G4	Long term plans	2.52	63.00	Moderately Important
23	B	Work Classification and Weekly Schedule	2.50	62.50	
24	B3	Weekly scheduling for conducting works.	2.50	62.50	Moderately Important
25	B2	Developing & implementing work processing procedure	2.44	61.00	Moderately Important
26	F1	Defining accepted and applied backlog	2.40	60.00	Moderately Important
27	F	Backlog of Funded works	2.32	58.00	
28	F3	Backlog reports review and analysis	2.32	58.00	Moderately Important
29	F2	Backlog summaries of approved works	2.24	56.00	Moderately Important
		Total		**1966.42**	
		Average Score		**67.81**	

Table 5.9-4 - Ranking Summary Table for Government Sector Samples
Forth Component : Work Accomplishment

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	B4	Material and equipment availability	3.43	85.87	Important
2	G3	Monitored contract performance	3.12	78.00	Important
3	F2	Clear supervisor responsiblities	3.04	76.00	Important
4	G2	Contract administration by experienced and trained personnel.	3.04	76.00	Important
5	F1	Spending enough percentage of supervisor's time on direct supervision.	3.00	75.00	Important
6	B	Craft and Material Availability	2.97	74.25	
7	B3	Material scheduling for individual work orders	2.96	74.00	Important
8	D2	Tools and equipment adequacy	2.96	74.00	Important
9	E1	Adequate number of vehicles for maint. transportation	2.96	74.00	Important
10	F	Supervisory Practices	2.92	73.00	
11	E3	Tools availability	2.92	73.00	Important
12	E	Transportation	2.91	72.75	
12	G	Use of Contracts	2.90	72.50	
14	B1	Craft distribution planning for shop workforce	2.84	71.00	Important
15	E2	Adequate operation & maintenance of vehicles	2.84	71.00	Important
16	F4	Labor and material cost estimation	2.83	70.83	Important
14	D	Shop, Spaces, Tools & Equipment	2.80	70.00	
18	A1	Establishing weekly scheduling	2.80	70.00	Important
19	C1	Desiging key maintenance processes	2.80	70.00	Important
20	F3	Identifying training & safety programs by supervisors	2.80	70.00	Important
21	G4	Frequent management evaluation and comparison between contract and in-house performance.	2.80	70.00	Important
22	C4	Establishing performance indicators	2.79	69.79	Important
23	D3	Maintained shop and facilities condition	2.76	69.00	Important
24	C	Maintenance Process Re-engineering	2.74	68.50	Moderately Important
25	C3	Quality cost measuring	2.72	68.00	Moderately Important
26	A3	Performance within +/- 10% of planned works	2.68	67.00	Moderately Important
27	D1	Shop space adequacy	2.68	67.00	Moderately Important
28	B2	Work ordering scheduling for craft hours	2.64	66.00	Moderately Important
29	C2	Work process automation	2.64	66.00	Moderately Important
30	G1	Balancing contracts and in-house staff	2.64	66.00	Moderately Important
31	A	Shop Scheduling & Planning Procedure	2.61	65.25	Moderately Important
32	A2	Documenting & reviewing scheduling procedures wkly	2.56	64.00	Moderately Important
33	A4	Shop planning support availability	2.40	60.00	Moderately Important
		Total		**2337.74**	
		Aveage Score		**70.84**	

Table 5.9-5 - Ranking Summary Table for Government Sector Samples
Fifth Component : Information Technology & Appraisal

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	D1	Availability of facility history records	2.96	74.00	Important
2	D3	Spare parts information	2.92	73.00	Important
3	D	Information Systems & Historical Records	2.87	71.75	Important
4	A2	Report design and utilization	2.88	72.00	Important
5	C1	Frequency productivity studies	2.88	72.00	Important
6	A4	Easy to use maintenance management system	2.84	71.00	Important
7	B1	Using performance measurment methods	2.84	71.00	Important
8	C2	Conducting work sampling of representative shop work force	2.84	71.00	Important
9	D2	Availability of equipment history records	2.84	71.00	Important
10	C	Productivity Measurement	2.82	70.50	Important
11	B2	Report summaries preparation	2.80	70.00	Important
12	C3	Comparisons of various categories of work	2.80	70.00	Important
13	D4	Computerized inventory system	2.76	69.00	Important
14	E1	Review policy for variance between planned and actual activities.	2.76	69.00	Important
15	C4	Conducting improvement action plan	2.75	68.75	Important
16	A	Management Information System (MIS)	2.73	68.25	Moderately Important
17	B	Measurement of Performance	2.72	68.00	Moderately Important
18	A3	Facility and equipment reports	2.72	68.00	Moderately Important
19	E2	Establishing parameters and guidelines for conducting these reviews	2.72	68.00	Moderately Important
20	A1	Maintenance MIS adequacy	2.68	67.00	Moderately Important
21	B3	Using engineered performance standards to estimate labor hours on work orders.	2.68	67.00	Moderately Important
22	E	Variance Review	2.67	66.75	Moderately Important
23	B4	Conducting improvement studies	2.56	64.00	Moderately Important
24	A5	Using expert systems	2.52	63.00	Moderately Important
25	E3	Variance records and periodic review.	2.52	63.00	Moderately Important
		Total		**1727.00**	
		Average Score		**69.08**	

Table 5.9-6 - Ranking Summary Table for Government Sector Samples
Sixth Component : Material Management

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	A2	Documentation of material used on work order sheet	3.28	82.00	Important
2	A3	Spare parts availability	3.24	81.00	Important
3	A	Parts & Material Availability	3.08	77.00	
4	B1	Storeroom control procedure and record system	3.04	76.00	Important
5	B2	Security and accessibility	3.04	76.00	Important
6	B3	Stock safety	3.04	76.00	Important
7	B	Storeroom Operation	2.92	73.00	
8	A1	Periodic inventory review	2.72	68.00	Moderately Important
9	C1	Purchase orders cost management	2.60	65.00	Moderately Important
10	B4	Integration of salvage and 'bench stock' with inventory control.	2.56	64.00	Moderately Important
11	C	Inventory Functions and Costs	2.45	61.25	Moderately Important
12	C2	Materials handling cost management	2.40	60.00	Moderately Important
13	C3	Materials stock out cost management.	2.36	59.00	Moderately Important
		Total		**918.25**	
		Average Score		**70.63**	

Table 5.10-1 - Ranking Summary Table for Private Sector Samples
First Component : Organization & Human Resources

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	C1	Clear work control responsibilities	3.73	93.18	Extremely Important
2	G1	Technical training	3.64	90.91	Extremely Important
3	A1	Availability of organization chart	3.59	89.77	Extremely Important
4	A3	Job description for each position	3.55	88.64	Extremely Important
5	C4	Planning staff sufficiency	3.50	87.50	Extremely Important
6	C	Work Control Center Functions, Stffing	3.46	86.50	Important
7	B1	Availability of general policies & objectives documentation	3.45	86.36	Important
8	B2	Complete services organization clearly defined.	3.45	86.36	Important
9	C3	Work reception staff training	3.45	86.36	Important
10	A	Organization Structure	3.41	85.25	Important
11	G2	Productivity training	3.36	84.09	Important
12	H1	Conducting a climate survey	3.36	84.09	Important
13	H4	Employee awards and recognition	3.36	84.09	Important
14	B	Policies, Rules and Services	3.35	83.75	Important
15	C2	Effectiveness evaluation and review	3.32	82.95	Important
16	C5	Establishing of data analysis for management use	3.32	82.95	Important
17	D1	Availability of documented shop functions	3.32	82.95	Important
18	F1	Ratio of supervisors to craft workers	3.32	82.95	Important
19	F3	Labor productivity follow up	3.32	82.95	Important
20	F	First line supervisions & responsibilities	3.29	82.25	Important
21	G	Training	3.29	82.25	Important
22	A4	Data updating procedure	3.27	81.82	Important
23	H2	Annual turnover due to quits & discharges of labors	3.27	81.82	Important
24	H3	Employees financial motivation	3.27	81.82	Important
25	H	Motivation	3.24	81.00	Important
26	A2	Availability of function statement for all components which define roles, authority & responsibility.	3.24	80.95	Important
27	D2	Clear related crafts relationships	3.23	80.68	Important
28	F2	Availability of adequate support staff	3.23	80.68	Important
29	D	Shop organization	3.15	78.75	Important
30	B3	Availability of active updating procedure	3.14	78.41	Important
31	E1	Multi-craft job coordiantion	3.09	77.27	Important
32	E	Shop supervision & planning functions	3.02	75.50	Important
33	E3	Establishment of planning functions to support shop supervisors.	3.00	75.00	Important
34	E2	Supervision coverage adequacy	2.95	73.86	Important
35	D3	Effectiveness review and evaluation	2.91	72.73	Important
36	H5	Less barriers between labor and management	2.91	72.73	Important
37	G3	Management training	2.86	71.59	Important
		Total		**3040.71**	
		Average Score		**82.18**	

Table 5.10-2 - Ranking Summary Table for Private Sector Samples
Second Component : Work Load Identification & Performance Measures

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	B1	Availability of work order system	3.82	95.45	Extremely Important
2	B	Work Request Procedure	3.59	89.75	Extremely Important
3	B2	Availability of documented procedure	3.55	88.64	Extremely Important
4	D1	Planned preventive maintenance	3.50	87.50	Extremely Important
5	B3	Information feedback to requester	3.41	85.23	Important
6	C1	Personnel understanding of their works relationships	3.41	85.23	Important
7	G1	Establishing prioritization of all works	3.41	85.23	Important
8	C3	Team work assignment for the same jobs	3.36	84.09	Important
0	C	Relationship Between Sections	3.35	83.75	Important
10	A2	Availability of documented inspection scheduling	3.32	82.95	Important
11	A	Facility Condition Inspection	3.27	81.75	Important
12	A1	Availability of inspection staff	3.27	81.82	Important
13	C2	Jobs description of each section	3.27	81.82	Important
14	D	Preventive Maintenance (Equipment)	3.26	81.50	Important
15	A3	Conducting maintenance & repairs based on inspection	3.23	80.68	Important
16	G	Work Requirements Documentation	3.20	80.00	Important
17	D3	Periodically reviewing equipment history records	3.18	79.55	Important
18	G2	Summarizing works by status	3.18	79.55	Important
19	D2	Accomplishing preventive maintenance work	3.09	77.27	Important
		within 10% of schedule.			Important
20	G3	Reviewing work load periodically	3.00	75.00	Important
21	F2	Reporting standing work order scheduling &	2.68	67.05	Moderately Important
		performance weekly.			
22	F3	Cost estimation of recurring work	2.68	67.05	Moderately Important
23	F	Routine, Recurring Work	2.64	66.00	
24	E1	Classifying service works separately from service works	2.64	65.91	Moderately Important
25	F1	Classifying recurring work to be controlled separately	2.55	63.64	Moderately Important
26	E	Service Work.	2.48	62.00	Moderately Important
27	E2	Clearly documenting processing procedure of	2.41	60.23	Moderately Important
		Service works.			Moderately Important
28	E3	Conducting work load analysis.	2.41	60.23	Moderately Important
		Total		**2178.87**	
		Average Score		**77.82**	

Table 5.10-3 - Ranking Summary Table for Private Sector Samples
Third Component : Work Planning & Scheduling

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	G1	Minimizing emergency work occurrence.	3.73	93.18	Extremely Important
2	D1	Planning annual maintenance budget	3.64	90.91	Extremely Important
3	G3	Shutdown scheduling and planning	3.64	90.91	Extremely Important
4	D	Budget Requirements for Maintenance and Repairs	3.48	87.00	Important
5	G	Emergency works & shutdown scheduling	3.45	86.25	Important
6	E3	Controlling budget against plans	3.45	86.36	Important
7	D2	Cost reporting and budget documetnation	3.41	85.23	Important
8	D3	Formally identifying and presenting long range requirements for renewals and replacement to fincncial managers.	3.41	85.23	Important
9	E2	Identifying works in the budget plan	3.41	85.23	Important
10	E	Budget Execution Plan	3.39	84.75	Important
11	A2	Appropriateness of priority criteria	3.32	82.95	Important
12	E1	Establishing periodic budget execution planning periodically.	3.32	82.95	Important
13	G2	Standard time assessment of specific works	3.32	82.95	Important
14	A3	Consistency of priority criteria	3.27	81.82	Important
15	F1	Defining accepted and applied backlog	3.27	81.82	Important
16	F	Backlog of Funded Works	3.20	80.00	Important
17	F3	Backlog reports review and analysis	3.18	79.55	Important
18	C3	Distribution of work force within a planned target	3.14	78.41	Important
19	F2	Backlog summaries of approved works	3.14	78.41	Important
20	G4	Long term plans	3.14	78.41	Important
21	B3	Weekly scheduling for conducting works	3.09	77.27	Important
22	C1	Classifying alteratins and improvement separately from maintenance works.	3.09	77.27	Important
23	C	Alterations and Improvement work	3.08	77.00	Important
24	B	Work classification and weekly schedule	3.06		Important
25	B1	Work classification for all tasks.	3.05	76.14	Important
26	B2	Developing and implementing work processing procedure	3.05	76.14	Important
27	C2	Processing and programming work seprately from maintenance.	3.00	75.00	Important
28	A	Priority System	2.86	71.50	Important
29	A1	Documentation and distribution of priority criteria.	2.00	50.00	Moderately Important
		Total		**2262.64**	
		Aveage Score		**78.02**	

Table 5.10-4 - Ranking Summary Table for Private Sector Samples
Fourth Component : Work Accomplishment

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	F1	Spending enough percentage of supervisor's time on direct supervision.	3.59	89.77	Extremely Important
2	F3	Identifying training & safety programs by supervisors	3.45	86.36	Important
3	F	Supervisory Practices	3.41	85.25	Important
4	F2	Clear supervisory responsibilities	3.41	85.23	Important
5	B1	Craft distribution planning for shop work force.	3.36	84.09	Important
6	A1	Establishing weekly scheduling	3.32	82.95	Important
7	G4	Frequent management evaluation and comparisons between contract and in-house performance	3.32	82.95	Important
8	B2	Work ordering scheduling for craft hours.	3.27	81.82	Important
9	B4	Material and equipment availability	3.27	81.82	Important
10	B	Craft and material availability	3.24	81.00	Important
11	D1	Shop space adequacy	3.23	80.68	Important
12	G3	Tools availability	3.23	80.68	Important
13	G	Use iof Contracts	3.18	79.50	Important
14	F4	Labors and material cost estimation	3.18	79.55	Important
15	G2	Contract admin. By experienced & trained personnel	3.18	79.55	Important
16	A2	Documenting & reviewing scheduling procedures wkly	3.14	78.41	Important
17	D	Shop, Spaces, Tools & Equipment	3.05	76.25	Important
18	B3	Material scheduling for individual work orders.	3.05	76.14	Important
19	D2	Tools and equipment adequacy	3.05	76.14	Important
20	E1	Adequate No. of vehicles for maint. transportation	3.05	76.14	Important
21	A	Shop Scheduling & planning Procedure	3.02	75.50	Important
22	C1	Desiging key maintenance processes	3.00	75.00	Important
23	E3	Tools availability	3.00	75.00	Important
24	G1	Balancing contracts and in-house staff.	3.00	75.00	Important
25	C2	Work process automation	2.95	73.86	Important
26	C3	Quality cost mesuring	2.95	73.86	Important
27	E	Transportation	2.91	72.75	Important
28	C	Maintenance Process Re-Engineering	2.91	72.75	Important
29	A3	Performance within +/- 10% of planned works	2.91	72.73	Important
30	D3	Maintained shop and facilities condition	2.86	71.59	Important
31	A4	Shop planning support availability	2.73	68.18	Moderately Important
32	C4	Establishing performance indicators	2.73	68.18	Moderately Important
33	E2	Adequate operation & maintenance of vehicles.	2.68	67.05	Moderately Important
		Total		**2565.73**	
		Average Score		**77.75**	

Table 5.10-5 - Ranking Summary Table for Private Sector Samples
Fifth Component : Information Technology & Appraisal

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	D3	Spare parts information	3.45	86.36	Important
2	D	Information System & Historical Records	3.33	83.25	Important
3	A4	Easy to use maintenance management system	3.32	82.95	Important
4	C1	Frequent productivity studies	3.32	82.95	Important
5	D1	Availability of facility history records	3.32	82.95	Important
6	D2	Availability of equipment history records	3.32	82.95	Important
7	A1	Maintenance MIS adequacy	3.27	81.82	Important
8	B1	using performance measurement methods	3.27	81.82	Important
9	B2	Report summaries preparation	3.23	80.68	Important
10	B4	Conducting improvement studies	3.23	80.68	Important
11	D4	Computerized inventry system	3.23	80.68	Important
12	B	Measurement of Performance	3.22	80.50	Important
13	A	Management Information System (MIS)	3.18	79.50	Important
14	A2	Report design and utilization	3.18	79.55	Important
15	A3	Facility and equipment reports	3.18	79.55	Important
16	C3	Comparisons of various categories of work	3.18	79.55	Important
17	C	Productivity Measurement	3.15	78.75	Important
18	B3	Using engineered performance standards to estimate labor hours on work orders.	3.14	78.41	Important
19	A5	Using exper systems	2.95	73.86	Important
20	C2	Conducting work sampling of representative shop work force	2.95	73.86	Important
21	E1	Review policy for variance between planned and actual activities	2.91	72.73	Important
22	E3	Variance records and periodic review	2.82	70.45	Important
23	E2	Establishing parameters and guidelines for conducting these reviews.	2.68	67.05	Moderately Important
24	E	Variance Review	2.80	70.00	Important
		Total		**1820.85**	
		Average Score		**75.87**	

Table 5.10-6 - Ranking Summary Table for Private Sector Samples
Sixth Component : Material Management

Rank	Auditing Factor		Mean Value	Importance Index	Ordinal Scale
1	A3	Spare parts availability	3.64	90.91	Extremely Important
2	B2	Security and accessibility	3.59	89.77	Extremely Important
3	B1	Storeroom control procedure and record system	3.55	88.64	Extremely Important
4	A	Parts & Material Availability	3.48	87.00	Important
5	A1	Periodic inventory review	3.41	85.23	Important
6	A2	Documentation of material used on work order sheet.	3.41	85.23	Important
7	B3	Stock safety	3.41	85.23	Important
8	B	Storeroom operation	3.23	80.75	Important
9	C1	Purchase orders cost management	3.00	75.00	Important
10	C	Inventory Functions and costs	2.68	67.00	Moderately Important
11	C2	Materials handling cost management	2.55	63.64	Moderately Important
12	C3	Materials stock out cost management	2.50	62.50	Moderately Important
13	B4	Integration of salvage and 'bench stock' with inventory control.	2.36	59.09	Moderately Important
		Total		**1019.99**	
		Average Score		**78.46**	

Table 5.11-1 - Comparison Table

First Component: Organization & Human Resources

Factor No	Question	Total No. of Respondents	Govt Importance Index	Pvt Importance Index	Cumlative Average Mean	Cumulative Importance Index (%)	Ordinal Scale
A	**Organization Structure**	47	3.12	3.41	3.26	81.50	Important
1	Availability of organization chart	47	3.04	3.59	3.30	82.50	Important
2	Availability of function statement for all components which define roles, authority and responsibility.	45	3.00	3.24	3.11	77.75	Important
3	Job description for each position	46	3.42	3.55	3.48	87.00	Important
4	Data updating procedure	47	3.04	3.27	3.15	78.75	Important
B	**Policies, Rules and Services**	47	3.00	3.35	3.16	79.00	Important
1	Availability of general policies and objectives documentation.	47	3.08	3.45	3.25	81.25	Important
2	Complete services organization clearly defined	47	3.08	3.45	3.25	81.25	Extremely Imp.
3	Availability of active updating procedure	47	2.84	3.14	2.98	74.50	Important
C	**Work Control Center Functions, Staffing**	46	3.12	3.46	3.28	82.00	Important
1	Clear work control responsibilities.	47	3.20	3.73	3.45	86.25	Important
2	Effectiveness evaluation and review	47	3.16	3.32	3.23	80.75	Important
3	Work reception staff training	47	3.08	3.45	3.25	81.25	Important
4	Planning staff sufficiency	47	3.08	3.50	3.28	82.00	Important
5	Establishing of data analysis for management use.	47	3.08	3.32	3.19	79.75	Important
D	**Shop Organization**	47	2.97	3.15	3.05	76.25	Important
1	Availability of documented shop functions	47	2.92	3.32	3.11	77.75	Important
2	Clear related crafts relationships	47	3.12	3.23	3.17	79.25	Important
3	Effectiveness review and evaluation	46	2.88	2.91	2.89	72.25	Important
E	**Shop Supervision & Planning Functions**	46	2.68	3.02	2.84	71.00	Important
1	Multi-craft job coordination	47	2.80	3.09	2.94	73.50	Important
2	Supervision coverage adequacy	46	2.79	2.95	2.87	71.75	Important
3	Establishment of planning functions to support shop supervisors.	47	2.44	3.00	2.70	67.50	Moderately Important
F	**First Line Supervision & Responsibilities**	46	2.93	3.29	3.10	77.50	Important
1	Ratio of supervisors to craft workers	47	3.00	3.32	3.15	78.75	Important
2	Availability of adequate support staff	47	2.80	3.23	3.00	75.00	Important
3	Labor productivity follow-up	47	3.00	3.32	3.15	78.75	Important

Table 5.11-1 - Comparison Table

First Component: Organization & Human Resources (Contd)

Factor No	Question	Total No. of Respondents	Govt Importance Index	Pvt Importance Index	Cumulative Average Mean	Cumulative Importance Index (%)	Ordinal Scale
G	**Training**	47	2.86	3.29	3.06	76.50	Important
1	Technical training	47	3.00	3.64	3.30	82.50	Important
2	Productivity training	47	2.76	3.36	3.04	76.00	Important
3	Management training	46	2.83	2.86	2.84	71.00	Important
H	**Motivation**	47	2.72	3.24	2.96	74.00	Important
1	Conducting a climate survey	45	2.67	3.36	2.99	74.75	Important
2	Annual turnover due to quits and discharges of labors.	47	2.44	3.27	2.83	70.75	Important
3	Employees financial motivation	47	2.80	3.27	3.02	75.50	Important
4	Employees awards and recognition	47	2.96	3.36	3.15	78.75	Important
5	Less barriers between labor and management	47	2.72	2.91	2.81	70.25	Important
	Total	1728	108.43	121.62	114.62	2864.75	
	Average Score	46.70	2.93	3.29	3.10	77.44	Important

Table 5.11-2 - Comparison Table

Second Component: Work Load Identification & Performance Measures

Factor No	Question	Total No. of Respondents	Govt Importance Index	Pvt Importance Index	Cumulative Average Mean	Cumulative Importance Index (%)	Ordinal Scale
A	**Facility Condition Inspection**	47	3.01	3.27	3.13	78.25	Important
1	Availability of inspection staff	47	3.04	3.27	3.15	78.75	Important
2	Availability of documented inspection scheduling	47	3.00	3.32	3.15	78.75	Important
3	Conducting maintenance & repairs based on inspection	47	3.00	3.23	3.11	77.75	Important
B	**Work Request Procedure**	47	3.17	3.59	3.37	84.25	Important
1	Availability of work order system	47	3.48	3.82	3.64	91.00	Extremely Imp.
2	Availability of documented procedure	47	3.04	3.55	3.28	82.00	Important
3	Information feedback to requester	47	3.00	3.41	3.19	79.75	Important
C	**Relationship Between Sections**	47	3.00	3.35	3.16	79.00	Important
1	Personnel understanding of their works relationships.	47	3.12	3.41	3.26	81.50	Important
2	Job description of each section	47	3.00	3.27	3.13	78.25	Important
3	Team work assignment for the same jobs	47	2.88	3.36	3.10	77.50	Important
D	**Preventive Maintenance (Equipment)**	46	2.95	3.26	3.10	77.50	Important
1	Planned preventive maintenance	47	3.04	3.50	3.26	81.50	Important
2	Accomplishing preventive maintenance work within 10% of schedule.	46	2.92	3.09	3.00	75.00	Important
3	Periodically reviewing equipment history records.	47	2.88	3.18	3.02	75.50	Important
E	**Service Work**	47	2.16	2.48	2.31	57.75	Moderately Imp.
1	Classifying service works separately from other works.	47	2.36	2.64	2.49	62.25	Moderately Imp.
2	Clearly documenting processing procedure of service works.	47	2.16	2.41	2.28	57.00	Moderately Imp.
3	Conducting work load analysis.	47	1.96	2.41	2.17	54.25	Moderately Imp.
F	**Routine, Recurring Work**	47	2.27	2.64	2.44	61.00	Moderately Imp.
1	Classifying recurring work to be controlled separately.	47	2.16	2.55	2.34	58.50	Moderately Imp.

Table 5.11-2 - Comparison Table

Second Component: Work Load Identification & Performance Measures (Contd)

Factor No	Question	Total No. of Respondents	Govt Importance Index	Pvt Importance Index	Cumulative Average Mean	Cumulative Importance Index (%)	Ordinal Scale
2	Reporting standing work order scheduling & performance weekly.	47	2.32	2.68	2.49	62.25	Moderately Imp.
3	Cost estimation of recurring work	47	2.32	2.68	2.49	62.25	Moderately Imp.
G	**Work Requirements Documentation**	47	2.65	3.20	2.91	72.75	Important
1	Establishing prioritization of all works	47	2.96	3.41	3.17	79.25	Important
2	Summarizing works by status	47	2.64	3.18	2.89	72.25	Important
3	Reviewing work load periodically	47	2.36	3.00	2.66	66.50	Moderately Imp.
	Total	1314	76.85	87.16	81.68	2042.25	
	Average Score	46.93	2.74	3.11	2.92	72.93	Important

Table 5.11-3 - Comparison Table
Third Component: Work Planning and Scheduling

Factor No	Question	Total No. of Respondents	Govt. Importance Index	Private Importance Index	Cumulative Average Mean	Cumulative Importance Index (%)	Ordinal Scale
A	**Priority System**	47	2.88	2.86	2.87	71.75	Important
1	Documentation & distribution of priority criteria	47	2.88	2.00	2.47	61.75	Moderately Imp.
2	Appropriateness of priority criteria	46	2.92	3.32	3.11	77.75	Important
3	Consistency of priority criteria	47	2.84	3.27	3.04	76.00	Important
B	**Work Classification and Weekly Schedule**	47	2.50	3.06	2.76	69.00	Important
1	Work Classification for all tasks.	47	2.56	3.05	2.79	69.75	Important
2	Developing and implementing work processing procedure.	47	2.44	3.05	2.73	68.25	Moderately Imp.
3	Weekly scheduling for conducting works.	46	2.50	3.09	2.78	69.50	Important
C	**Alterations and Improvement Work**	47	2.65	3.08	2.85	71.25	Important
1	Classifying alterations and improvement separately from maintenance works.	47	2.68	3.09	2.87	71.75	Important
2	Processing and programming of work separately from maintenance.	47	2.60	3.00	2.79	69.75	Important
3	Distribution of work force within a planned target.	47	2.68	3.14	2.90	72.50	Important
D	**Budget Requirements for Maintenance and Repairs**	47	2.96	3.48	3.20	80.00	Important
1	Planning annual maintenance budget.	47	3.00	3.64	3.30	82.50	Important
2	Cost reporting & budget documentation	47	2.92	3.41	3.15	78.75	Important
3	Formally identifying and presenting long-range re requriements for renewals and replacement to financial managers.	47	2.96	3.41	3.17	79.25	Important
E	**Budget Execution Plan**	47	2.84	3.39	3.10	77.44	Important
1	Establishing periodic budget execution planning periodically.	47	2.80	3.32	3.04	76.09	Important
2	Identifying works in the budget plan.	47	2.96	3.41	3.17	79.27	Important
3	Controlling budget against plans	47	2.76	3.45	3.08	77.07	Important

Table 5.11-3 - Comparison Table
Third Component: Work Planning and Scheduling (Contd)

Factor No	Question	Total No. of Respondents	Govt. Importance Index	Private Importance Index	Cumulative Aveage Mean	Cumulative Importance Inde (%)	Ordinal Scale
F	**Backlog of Funded Works**	47	2.32	3.20	2.73	68.30	Moderately Imp.
1	Defining accepted and applied backlog	47	2.40	3.27	2.81	70.18	Important
2	Backlog summaries of approved works	47	2.24	3.14	2.66	66.53	Moderately Imp.
3	Backlog reports review and analysis	47	2.32	3.18	2.72	68.06	Important
G	**Emergency Works & Shutdown Scheduling**	47	2.81	3.45	3.11	77.74	Important
1	Minimizing emergency work occurrence	47	3.12	3.73	3.41	85.14	Important
2	Standard time assessment of specific works	47	2.92	3.32	3.11	77.68	Important
3	Shutdown scheduling and planning	47	2.68	3.64	3.13	78.23	Important
4	Long term plans	47	2.52	3.14	2.81	70.26	Important
	Total	1361	78.66	93.59	85.66	2141.48	
	Average Score	46.93	2.71	3.23	2.95	73.84	Important

Table 5.11-4 - Comparison Table
Fourth Component: Work Accomplishment

Factor No	Question	Total No. of Respondents	Govt. Importance Index	Pvt Importance Index	Cumulative Average Mean	Cumulative Importance Index (%)	Ordinal Scale
A	**Shop Scheduling & Planning Procedure**	47	2.61	3.02	2.80	70.00	Important
1	Establishing weekly scheduling	47	2.80	3.32	3.04	76.00	Important
2	Documenting & reviewing scheduling procedures weekly.	47	2.56	3.14	2.83	70.75	Important
3	Performance within +10% of planned works.	47	2.68	2.91	2.79	69.75	Important
4	Shop planning support availability	47	2.40	2.73	2.55	63.75	Important
B	**Craft and Material Availability**	47	2.97	3.24	3.10	77.50	Important
1	Craft distribution planning for shop workforce.	47	2.84	3.36	3.08	77.00	Important
2	Work ordering Scheduling for craft hours	47	2.64	3.27	2.93	73.25	Important
3	Material scheduling for individual work orders	47	2.96	3.05	3.00	75.00	Important
4	Material and equipment availability	45	3.43	3.27	3.35	83.75	Important
C	**Maintenance Process Re-Engineering**	47	2.74	2.91	2.82	70.50	Important
1	Designing Key maintenance processes	47	2.80	3.00	2.89	72.25	Important
2	Work process automation	47	2.64	2.95	2.79	69.75	Important
3	Quality cost measuring	47	2.72	2.95	2.83	70.75	Important
4	Establishing performance indicators.	46	2.79	2.73	2.76	69.00	Important
D	**Shop, Spaces, Tools & Equipment**	47	2.80	3.05	2.92	73.00	Important
1	Shop space adequacy	47	2.68	2.23	2.47	61.75	Moderately Imp.
2	Tools and equipment adequacy	47	2.96	3.05	3.00	75.00	Important
3	Maintained shop and facilities condition	47	2.76	2.86	2.81	70.25	Important
E	**Transportation**	47	2.91	2.91	2.91	72.75	Important
1	Adequate number of vehicles for	47	2.96	3.05	3.00	75.00	Important
2	maintenance transportation. Adequate operation & maintenance of vehicles	47	2.84	2.68	2.77	69.25	Important
3	Tools availability	47	2.92	3.00	2.96	74.00	Important
F	**Supervisory Practices**	47	2.92	3.41	3.15	78.75	Important
1	Spending enough percentage of supervisor's time on direct supervision.	47	3.00	3.59	3.28	82.00	Important
2	Clear supervisory responsibilities	47	3.04	3.41	3.21	80.25	Extremely Imp.

Table 5.11-4 - Comparison Table
Fourth Component: Work Accomplishment (Contd)

Factor No	Question	Total No. of Respondents	Govt. Importance Index	Pvt Importance Index	Cumulative Average Mean	Cumulative Importance Index (%)	Ordinal Scale
3	Identifying training & safety programs by supervisors.	47	2.80	3.45	3.10	77.50	Important
4	Labor and material cost estimation	46	2.83	3.18	3.00	75.00	Important
G	**Use of Contracts**	47	2.90	3.18	3.03	75.75	Important
1	Balancing contracts and in-house staff	47	2.64	3.00	2.81	70.25	Important
2	Contract administration by experienced and trained personnel.	47	3.04	3.18	3.11	77.75	Important
3	Monitored contract performance	47	3.12	3.23	3.17	79.25	Important
4	Frequent management evaluation and comparisons comparisons between contract & in-house performance.	47	2.80	3.32	3.04	76.00	Important
	Total	1547	93.5	101.63	97.31	2432.5	
	Average Score	46.88	2.83	3.08	2.95	73.72	Important

Table 5.11-5 - Comparison Table
Fifth Component: Information Technology and Appraisal

No	Question	Total No. of Respondents	Govt. Importance Index	Private Importance Index	Cumulative Average Mean	Cumulative Importance Index (%)	Ordinal Scale
A	**Management Information System (MIS)**	47	2.73	3.18	2.94	73.50	Important
1	Maintenance MIS adequacy	47	2.68	3.27	2.96	74.00	Important
2	Report design and utilization	47	2.88	3.18	3.02	75.50	Important
3	Facility and equipment reports	47	2.72	3.18	2.94	68.50	Moderately Imp.
4	Easy to use maintenance management system	47	2.84	3.32	3.06	76.50	Important
5	Using expert systems	47	2.52	2.95	2.72	68.00	Moderately Imp.
B	**Measurement of Performance**	47	2.72	3.22	2.95	73.75	Important
1	Using performance measurement methods	47	2.84	3.27	3.04	76.00	Important
2	Report summaries preparation	47	2.80	3.23	3.00	75.00	Important
3	Using engineered performance standards to estimate labor hours on work orders.	47	2.68	3.14	2.90	72.50	Important
4	Conducting improvement studies.	47	2.56	3.23	2.87	71.75	Important
C	**Productivity Measurement**	47	2.82	3.15	2.97	74.25	Important
1	Frequent productivity studies	47	2.88	3.32	3.09	77.25	Important
2	Conducting work sampling of representative shop workforce.	47	2.84	2.95	2.89	72.25	Important
3	Comparisons of various categories of work	47	2.80	3.18	2.98	74.50	Important
4	Conducting improvement action plan	46	2.75	3.08	2.91	72.75	Important
D	**Information System & Historical Records**	47	2.87	3.33	3.09	77.25	Important
1	Availability of facility history records	47	2.96	3.32	3.13	78.25	Important
2	Availability of equipment history records	47	2.84	3.32	3.06	76.50	Important
3	Spare parts information	47	2.82	3.45	3.11	77.75	Important
4	Computerized inventory system	47	2.76	3.23	2.98	74.50	Important
E	**Variance Review**	47	2.67	2.80	2.73	68.25	Moderately Imp.
1	Review policy for variance between planned and actual activities.	47	2.76	2.91	2.83	70.75	Important
2	Establishing parameters and guidelines for conducting these reviews.	47	2.72	2.68	2.70	67.50	Moderately Imp.
3	Variance records and periodic review	47	2.52	2.82	2.66	66.50	Moderately Imp.
	Total	1174	68.98	78.71	73.54	1833.25	
	Average Score	46.96	2.76	3.15	2.94	73.54	Important

Table 5.11-6 - Comparison Table
Sixth Component: Material Management

Factor No	Question	Total No. of Respondents	Govt. Importance Index	Private Importance Index	Cumulative Average Mean	Cumulative Importance Index	Ordinal Scale
A	**Parts & Material Availability**	47	3.08	3.48	3.27	81.75	Important
1	Periodic inventory review	47	2.72	3.41	3.04	76.00	Important
2	Documentation of material used on work order sheet.	47	3.28	3.41	3.34	83.50	Important
3	Spare parts availability	47	3.24	3.64	3.43	85.75	Important
B	**Storeroom Operation**	47	2.92	3.23	3.07	76.75	Important
1	Storeroom control procedure and record system	47	3.04	3.55	3.28	82.00	Important
2	Security and accessibility	47	3.04	3.59	3.30	82.50	Important
3	Stock Safety	47	3.04	3.41	3.21	80.25	Important
4	Integration of salvage and "bench stock" with inventory control.	47	2.56	2.36	2.47	61.75	Moderately Imp.
C	**Inventory Functions and Costs**	47	2.45	2.68	2.56	64.00	Moderately Imp.
1	Purchase orders cost management	47	2.60	3.00	2.79	69.50	Important
2	Materials handling cost management	47	2.40	2.55	2.47	61.75	Moderately Imp.
3	Materials stock out cost management	47	2.36	2.50	2.43	60.75	Moderately Imp.
	Total	611	36.73	40.81	38.64	966.25	
	Average Scale	47.00	2.83	3.14	2.97	74.31	Important

5.4 RECOMMENDED MAINTENANCE MANAGEMENT AUDIT FORM

From the Literature review, survey and data analysis, factors affecting building maintenance management in Saudi Arabia are listed and given a suitable importance index. The calculated importance index for each sub-factor determines the ordinal score, as mentioned earlier. Some respondents reveal that based on these findings and results a recommended maintenance management audit form is developed as shown in table 5.12. Each sub-factor is given a maximum score based on its calculated ordinal score such as: 4, 3 and 2 for extremely important, important and moderately important respectively. The auditor has to fill in the suitable socre in the earned score rank. The score should not exceed the maximum score for each sub-factor. At the end of each component, the auditor can calculate the effectiveness index of this component by multiplying the earned score by the weight shown in table 5.12 of the same factor to get the total score, for example effectiveness index for the first component can be:

$$= \frac{\text{Total Earned Score}}{\text{Maximum Score}} \times 100 = \frac{\text{Total Earned Score}}{87} \times 100$$

The same method is applied at the end of the auditing to find the average effectiveness index using the formula:

$$\left(\sum_{i=1}^{6} \frac{\text{Total earned score}}{\text{Total Max. Score}} \right) \times 100$$

$$= \left(\sum_{i=1}^{6} \{ \frac{\text{Total earned Score}}{369} \right)$$

From data analysis, it is found that each one of the six main components is ranked as important. The highest importance index is scored by organization and human resources (77.44%) while the lowest importance index is (72.93%) for work load identification and performance measures.

These main components of factors and sub-factors have approximately the same importance and each one affects the others, for example if the organization and human resources main component scores little effectiveness in one organizations, the other components will be affected badly.

Table 5.12 shows the recommended maintenance management audit form. It consists of factors that should be considered when conducting the audit with their scores. The same score scale used in this study to determine the importance index for each factor, also used in the developed form to score the effectiveness indices for these factors. These factors are suitable for the Saudi environment.

Table 5.12 Maintenance Management Audit Form

First Component: Organization & Human Resources

No	Questions	Weight	Score (Out of 10)	(Earned Score) x Weight
A	Organization Structure			
1.	Availability of organization chart			
2.	Availability of function statement for all components which define roles, authority & responsibility			
3.	Job description for each position			
4.	Data updating procedure			
B	Policies, Rules and Systems			
1.	Availability of general policies and objectives documentation			

No	Questions	Weight	Score (Out of 10)	(Earned Score) x Weight
2.	Complete services organization clearly defined	0.2		
3.	Availability of active updating procedure	0.2		
C.	Work Control Center Functions/ Staffing			
1.	Clear work control responsibilities	0.3		
2.	Effectiveness evaluation and review	0.3		
3.	Work reception staff training	0.2		
4.	Planning staff sufficiency	0.2		
5.	Establishing of data analysis for management use	0.3		
D.	Shop Organization			
1.	Availability of documented shop functions	0.3		
2.	Clear related crafts relationships	0.3		
3.	Effectiveness review and evaluation	0.4		
E.	Shop Supervision & Planning Functions			
1.	Multi-craft job coordination	0.3		
2.	Supervision coverage adequacy	0.3		
3.	Establishment of planning functions to support shop supervisors	0.4		
F.	First Line Supervision & Responsibilities			
1.	Ratio of supervisors to craft workers	0.3		
2.	Availability of adequate support staff	0.3		
3.	Labor productivity follow-up	0.4		
G.	Training			
1.	Technical training	0.3		
2.	Productivity training	0.3		
3.	Management training	0.4		
H.	Motivation			
1.	Conducting a climate survey	0.2		
2.	Annual turnover due to quits and discharges of laborers	0.3		
3.	Employees' financial motivation	0.2		
4.	Employees' awards and recognition	0.2		
5.	Less barriers between labor and management	0.1		
	TOTAL	Max. Score = 8		

Second Component: Work Load Identification & Performance Measures

No	Questions	Weight	Score (out of 10)	(Earned Score) x Weight
A.	Facility Condition Inspection			
1.	Availability of inspection staff	0.3		
2.	Availability of documented inspection scheduling	0.3		
3.	Conducting maintenance & repairs based on inspection	0.4		

No	Questions	Weight	Score (out of 10)	(Earned Score) x Weight
A.	Work Request Procedure			
1.	Availability of work order system	0.4		
2.	Availability of documented procedure	0.3		
3.	Information feedback to requester	0.3		
C.	Relationship Between Sections			
1.	Personnel understanding of their work relationships	0.4		
2.	Job description of each section	0.3		
3.	Team work assignment for the same jobs	0.3		
D.	Preventive Maintenance Equipment			
1.	Planned preventive maintenance	0.4		
2.	Accomplishing preventive maintenance work within 10% of schedule	0.3		
3.	Periodically reviewing equipment history records.	0.3		
E.	Service Work			
1.	Classifying service work separately from other work	0.4		
2.	Clearly documenting processing procedure of service work	0.2		
3.	Conducting work load analysis	0.4		
F.	Routine, Recurring Work			
1.	Classifying recurring work to be controlled separately	0.5		
2.	Reporting standing work order scheduling & performance weekly	0.3		
3.	Cost estimation of recurring work	0.2		
G.	Work Requirement Documentation			
1.	Establishing prioritization of all work	0.4		
2.	Summarizing jobs by status	0.3		
3.	Reviewing work load periodically	0.3		
	TOTAL	Max Score = 7.0		

Third Component: Work Planning & Scheduling

No	Questions	Weight	Score (out of 10)	(Earned Score) x Weight
A.	Priority System			
1.	Documentation & distribution of priority criteria	0.4		
2.	Appropriateness of priority criteria	0.3		
3.	Consistency of priority criteria	0.3		
B.	Work Classification and Weekly Schedule			
1.	Work Classification for all tasks	0.4		
2.	Developing and implementing work processing procedure	0.6		

No	Questions	Weight	Score (out of 10)	(Earned Score) x Weight
3.	Weekly scheduling for conducting work	0.3		
C.	Alterations and Improvement Work			
1.	Classifying alterations and improvement separately from maintenance work	0.3		
2.	Processing and programming of work separately from maintenance	0.3		
3.	Distribution of work force within aplanned target	0.3		
D.	Budget Requirements for Maintenance and Repairs			
1.	Planning annual maintenance budget	0.3		
2.	Cost reporting & budget documentation	0.3		
3.	Formally identifying and presenting long-range requirements for renewals and replacement to financial managers	0.3		
E.	Budget Execution Plan			
1.	Establishing periodic budget execution planning	0.3		
2.	Identifying works in the budget plan.	0.3		
3.	Controlling budget against expenditure	0.3		
F.	Backlog of Planned Work			
1.	Defining accepted and applied backlog	0.3		
2.	Backlog summaries of approved work	0.3		
3.	Backlog reports review and analysis	0.3		
G.	Emergency Work & Shutdown Scheduling			
1.	Minimizing emergency work occurrence	0.2		
2.	Standard time assessment for specific jobs	0.3		
3.	Shutdown scheduling and planning	0.3		
4.	Long term plans	0.2		
	TOTAL	Max. Score = 3.0		

Fourth Component: Work Accomplishment

No	Questions	Weight	Score (out of 10)	(Earned Score) x Weight
A.	Shop Scheduling & Planning Procedure			
1.	Establishing weekly scheduling	0.3		
2.	Documenting & reviewing scheduling procedures weekly	0.3		
3.	Performance within ±10% of planned works	0.3		
4.	Shop planning support availability	0.1		
B.	Craft and Material Availability			
1.	Craft distribution planning for shop workforce	0.2		
2.	Work ordering scheduling for craft hours	0.3		
3.	Material scheduling for individual work orders	0.3		
4.	Material and equipment availability	0.2		

No	Questions	Weight	Score (out of 10)	(Earned Score) x Weight
C.	Maintenance Process Re-Engineering			
1.	Designing Key maintenance processes	0.3		
2.	Work process automation	0.2		
3.	Quality cost measuring	0.2		
4.	Establishing performance indicators	0.3		
D.	Shop Spaces, Tools & Equipment			
1.	Shop space adequacy	0.3		
2.	Tools and equipment adequacy	0.3		
3.	Maintenance of conditions in shops and facilities	0.4		
E.	Transportation			
1.	Adequate number of vehicles for maintenance transportation	0.3		
2.	Adequate operation & maintenance of vehicles	0.3		
3.	Tools availability	0.4		
F.	Supervisory Practices			
1.	Spending high enough percentage of supervisor's time on direct supervision	0.4		
2.	Clear supervisory responsibilities	0.2		
3.	Identifying training & safety programs by supervisors	0.2		
4.	Labor and material cost estimation	0.2		
G.	Use of Contracts			
1.	Balancing contracts and in-house staff	0.3		
2.	Contract administration by experienced and trained personnel	0.2		
3.	Monitored contract performance	0.2		
4.	Frequent management evaluation and comparisons between contract and in-house performance	0.3		
	TOTAL	Max Score = 10		

Fifth Component: Information Technology & Appraisal

No	Questions	Weight	Score (out of 10)	(Earned Score) x Weight
A.	Management Information Systems (MIS)			
1.	Maintenance of MIS adequacy	0.2		
2.	Report design and utilization	0.2		
3.	Facility and equipment reports	0.2		
4.	Easy to use maintenance management system	0.2		
5.	Using expert systems	0.2		

No	Questions	Weight	Score (Out of 10)	(Earned Score) x Weight
B	Measurement Performance			
1.	Using performance measurement methods	0.3		
2.	Report summaries preparation	0.3		
3.	Using engineered performance standards to estimate labor hours on work orders	0.3		
4.	Conducting improvement studies	0.3		
C	Productivity Measurement			
1.	Frequent productivity studies	0.3		
2.	Conducting work sampling of representative shop workforce	0.3		
3.	Comparisons of various categories of work	0.3		
4.	Conducting improvement action plan	0.3		
D	Information System & Historical Records			
1.	Availability of facility history records	0.3		
2.	Availability of equipment history records	0.3		
3.	Spare parts information	0.3		
4.	Computerized inventory system	0.3		
E	Variance Review			
1.	Review policy for variance between planned and actual activities	0.3		
2.	Establishing parameters and guidelines for conducting these reviews	0.2		
3.	Variance records and periodic review	0.2		
	TOTAL	Max Score = 56		

Sixth Component: Material Management

No	Questions	Weight	Score (out of 10)	(Earned Score) x Weight
A	Parts & Material Availability			
1.	Periodic inventory review	0.2		
2.	Documentation of material used on work order sheet.	0.3		
3.	Spare parts availability	0.3		
B	Storeroom Operation			
1.	Storeroom control procedure and record system	0.3		
2.	Security and accessibility	0.3		
3.	Stock Safety	0.3		
4.	Integration of salvage and "bench stock" with inventory control	0.2		
C	Inventory Functions and Costs			
1.	Purchase orders cost management	0.3		
2.	Materials handling cost management	0.2		
3.	Materials stock out cost management	0.2		
	TOTAL	Max Score = 37		

The maintenance management system Effectiveness Index in your organization is measured as follows:

$$\sum_{i=1}^{6} \frac{\text{Total Earned Score}}{\text{Tatal Max. Score}} \times 100$$

$$= \sum_{i=1}^{6} \frac{\text{Total Earned Score}}{369} \times 100$$

The maintenance management system in the organization is:

- Extremely effective : 87.5 ≤ Effectiveness Index ≤ 100
- Effective : 68.75 ≤ Effectiveness Index < 87.5
- Moderately Effective : 43.75 ≤ Effectiveness Index < 68.75
- Little Effective : 25.00 ≤ Effectiveness Index < 43.75
- In-effective : Effectiveness Index < 25.0

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY

The importance of building maintenance management auditing, statement of the problem, and objectives of the study were introduced in Chapter One of this thesis. Also the scope and limitations, and significance of the study and its expected outcomes were outlined in the same chapter.

Chapter Two gave an introduction to the assessment of maintenance management principles and their definitions, forms and importance to maintenance management. Auditing, its definition, types and phases were also discussed in the same chapter.

Furthermore, Chapter Three discussed the key components of maintenance management auditing. These components were categorized into six major components, as follows:

1. Organization and Human Resources;
2. Work Load Identification & Performance Measures;
3. Work Planning and Scheduling;
4. Work Accomplishment;
5. Information Technology and Appraisal;
6. Material Management.

Each major component contains several factors and sub-factors. These factors and sub-factors were discussed in detail in Chapter Three.

Chapter Four discussed the research methodology, identification of factors affecting building maintenance management auditing, questionnaire design, scoring, sample size determination and analysis methodology. The questionnaire was designed mainly to assess factors affecting maintenance management auditing gathered from the literature review. It consists of two parts: the first part of the questionnaire was designed to give general information on the respondent to the questionnaire and on his organization. Part Two was designed as fill-in-the-blank responses with five options for the responses. The questionnaires were sent to government and private sector organizations in the eastern province of Saudi Arabia. Questionnaires were sent to 50 government organization and 50 large companies from the private sector. The total number of completed responses received were 25 and 22 from government and private sectors respectively.

Chapter Five discussed the data analysis and results. The data obtained from the survey were statistically analyzed. The mean value was calculated for each component, factor and sub-factor. An importance index was used as the scoring approach for ranking these factors according to their importance. Chapter Five also discussed the the major findings of the resarch, as well as the comparison between total, government and private sector responses.

6.2 CONCLUSIONS

Based on the results and findings of this research, the following major conclusions can be drawn:

I. General Information

1. Approximately half of the respondents of the total surveyed organizations (51%) who answered the questionnaire are Engineers/Architects, followed by Managers (35%), while the others (14%) are maintenance supervisors.

2. The highest percentage of respondent's years of experience in maintenance work (34%) is eleven to fifteen years, followed by six to ten years (25%), then up to five years (23%), whereas 17% of respondents have more than fifteen years experience.

3. Fifty five percent (55%) of respondents' organizations have more than 500 employees whereas (17%) of them have only up to 100 employees.

4. It was found that 80% of the respondents' organizations have more than 50 personnel in their maintenance department, whereas none of them have less than 11 personnel.

5. The survey indicated that 61.7% of the 47 respondents conduct maintenance management auditing in their departments. 48% of the

government organizations and 77.3% of private sector respondents conduct auditing.

6. From these total organizations conducting the auditing, 55% conduct the auditing every year, the others conduct the auditing twice a year, more than twice a year, or one time in several years.

7. Most of the organizations (59%) conduct the auditing through internal auditors, whereas 20% and 14% call consultants and external auditors respectively which are not high percentages.

II. Technical Information

1. The practices of building maintenance management were reviewed in the literature review and through the conducted survey. Also factors affecting building maintenance management auditing were assessed and identified through the literature review, the questionnaire was designed and sent to large governmental and private organizations in the eastern province of Saudi Arabia. Through the survey no respondents revealed other factors except two respondents who suggested that routine, recurring work and service work may be considered as one factor instead of two factors in the second component (work load identification and performance measures). Also some respondents suggested that the work control office should report directly to the director general of the maintenance department.

2. It is found that organizations in the private sector give more consideration to auditing of their maintenance management because

efficiency, performance, productivity and work quality have a direct effect on their business and subsequently on their return on investment, such as in hotels, malls, industrial and commercial organizations. For example the importance indicies given by government organizations for organization and human resources and material management are 73% and 70% respectively, while these two components score 82% and 78% respectively by private organizations.

3. The government and private sectors have ranked "work request procedure" factor as number 1. This means any maintenance management organization must have a work order central unit and a work request procedure to coordinate and process the maintenance works in a systematic manner. Also, both parties have ranked "service work and routine work" factors as the least important. It seems that both parties considered these factors can be easily managed and it would not have any difficulty in their execution.

4. All factors and sub-factors are generally ranked as either important or moderately important in the total samples. However private organizations consider some of the factors as extremely important. The private sector has given more consideration to maintain their construction since this issue affects their continuation in their business directly. Factors and sub-factors which are considered as "extremely important" by private organizations are:

    1. Clear work control responsibilities.
    2. Technical training.

3. Availability of organization chart.
4. Job description for each position.
5. Planning staff sufficiency.
6. Availability of work order system.
7. Work request procedure.
8. Availability of documented procedure.
9. Planned preventive maintenance.
10. Minimizing emergency work occurance.
11. Planning annual maintenance budget.
12. Shutdown scheduling and planning.
13. Spending enough percentage of supervisors time on direct supervision.
14. Spare parts availability.
15. Security and accessibility.
16. Store room control procedure and record system.

5. Agreement between governmental and private sector under 95% confidence was checked using the Spearman rule of Correlation Formula. It is found that they agree on ranking of all factors. Also, when a t-test is used to check the hypothesis, it is found that parties agree on ranking of factors.

6. There are no specific ready formats and techniques for maintenance audit applicable to all organizations. Therefore, and as a result of this lack, a guideline check list for factors to be audited is provided in this thesis.

7. Based on the literature review, the survey conducted in the eastern province of Saudi Arabia and data analysis, the six major components (each component composed of factors and sub-factors) affecting building maintenance management auditing in Saudi Arabia are ranked as follows:

First Component: Organization & Human Resources

A. Organization structure
B. Policies, Rules and Services
C. Work control center functions, staffing
D. Shop organization
E. Shop supervision & planning functions
F. First line supervision & responsibilities
G. Training
H. Motivation

Second Component:

Work Load Identification & Performance Measures

A. Facility condition inspection
B. Work request procedure
C. Relationship between sections
D. Preventive maintenance (equipment)
E. Service work
F. Routine, recurring work
G. Work requirements documentation

Third Component: Work Planning & Scheduling

A. Priority System
B. Work classification and weekly scheduling
C. Alterations and improvement work
D. Budget requirements for maintenance and repairs
E. Budget execution plan
F. Backlog of funded work
G. Emergency work & shutdown scheduling

Fourth Component: Work Accomplishment

A. Shop scheduling & planning procedure
B. Craft and material availability
C. Maintenance process re-engineering
D. Shop, spaces, tools & equipment
E. Transportation
F. Supervisor practices
G. Use of contracts

Fifth Component: Information Technology & Appraisal

A. Management Information System (MIS)
B. Measurement of performance
C. Productivity measurement
D. Information system & historical records
E. Variance review

Sixth Component: Material Management

A. Parts & material availability

B. Store room operation

C. Inventory functions and costs

8. Based on the literature review, responses to the questionnaires and data analysis, a form (Table 3.12) for building maintenance management auditing was developed, with the limitation that the study was conducted in the eastern province of Saudi Arabia and further survey and study needs to be conducted in other regions of Saudi Arabia.

6.3 RECOMMENDATIONS

Based on the results and conclusions of this study, the following recommendations are presented:

1. Large organizations should have internal maintenance auditors and ready formats and techniques suitable for their organization. However, external auditors and experts should participate in the audit to obtain complementary results and recommendations for improvement.

2. The organization structure of maintenance departments should be reviewed regularly to minimize conflicts between sections and to clarify authorities and responsibilities for sections and personnel.

3. Management of the work control center of maintenance departments should be given serious consideration. For example, qualified personnel should plan, follow-up and control the execution of

maintenance work. Also the work control center should be audited periodically due to its extreme importance.

4. Management should consider the training of their maintenance employees to motivate them to get greater productivity and performance. The training and motivation program should be reviewed on a regular basis to update the requirements and improve the program.

5. Material management should be activated in such areas as:
   a) Requirements for spare parts and materials should be determined considering the cost of purchasing, handling, storing and cost of stock-out.
   b) Store room control, record systems, security, accessibility and stock safety should be audited and reviewed regularly.

6. Work planning and scheduling should be considered when auditing the program of maintenance management. Good planners should be employed and trained to fix priority systems, classify work, report on maintenance costs and plan the annual maintenance budget.

7. The management should consider the audit of work accomplishments, such as availability of material, scheduling and planning procedures, maintenance process re-engineering, shop spaces and tools adequacy.

8. An adequate number of vehicles and tools is very important to the maintenance department. Organizations covering large areas should

have a good transportation system, since it directly affects maintenance labor productivity and satisfaction of the users.

9. Supervisors should be selected from good experienced staff and should be given clear responsibilities and areas of authority. They are very important agents in their departments since they guide and teach laborers, supervise them, identify training and safety programs, estimate material and labor costs, etc.

10. Balancing contracts and in-house staff is an important factor. The management should study carefully the advantages and disadvantages and evaluate the comparison between contract and in-house performance before a decision is taken.

11. The information technology and appraisal factor should be given more consideration by higher level authorities. Management information systems (MIS) helps in many aspects, such as in reports and productivity measurements.

12. Management of building maintenance should be aware of the importance of work load identification and performance measures to plan inspection of their facilities, design work request procedures and distinguish between different types of work according to their importance and classification.

13. Managers of building maintenance should not neglect:
    a) Auditing their programs on a regular basis.

b) Giving supervisors and experienced personnel the chance to improve their workshops and participate in decision making.

c) Reviewing reports carefully and studying improvement actions to be taken.

14. Auditing of maintenance management helps to improve the maintenance program's effectiveness in many ways, such as producing a better organizational structure, increasing productivity and effectiveness in achieving desired goals, as well as better utilization of resources.

6.4 RECOMMENDED FUTURE STUDIES

1. More studies and research need to be conducted in maintenance management fields, such as on evaluation and auditing of maintenance management systems. The survey of this study was conducted in the eastern province of Saudi Arabia, but is recommended to be done in other regions.

2. The developed building maintenance management auditing form is based on the literature review and survey in the eastern province of Saudi Arabia. It is recommended to be applied in the eastern province and in other regions to confirm its application suitability.

3. Developing maintenance laws and regulations to be followed by governmental organizations.

4. Assessment of factors affecting the productivity of maintenance departments in governmental organizations in Saudi Arabia.

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APPENDIX A

Details of Mean Values for Components, Factors and Sub-factors of Auditing

First Component: Organization and Human Resources (Government Sector)

Factor No	Description	No. of Respondents	Extremely Important %	Important %	Moderately Important %	Little Important %	Not Important %	Mean	Standard Deviation	Importance Index
A	**Organization Structure**	25	0.40	0.48	0.12	0.00	0.00	3.12	0.57	78.10
1	Availability of organization chart	25	0.32	0.52	0.08	0.04	0.00	3.04	0.56	76.00
2	Availability of function statement for all components which define roles, authority and responsibility	24	0.38	0.29	0.29	0.04	0.00	3.00	0.63	75.00
3	Job description for each position	24	0.42	0.50	0.13	0.00	0.00	3.42	0.49	85.42
4	Data updating procedure	25	0.28	0.52	0.16	0.04	0.00	3.04	0.52	76.00
B	**Policies, Rules and Services**	25	0.24	0.60	0.16	0.00	0.00	3.00	0.50	75.00
1	Availability of general policies and objectives documentation.	25	0.32	0.44	0.24	0.00	0.00	3.08	0.53	77.00
2	Complete services organization clearly defined	25	0.24	0.60	0.16	0.00	0.00	3.08	0.46	77.00
3	Availability of active updating procedure	25	0.24	0.36	0.40	0.00	0.00	2.84	0.59	71.00
C	**Work Control Center Functions, Staffing**	24	0.33	0.54	0.13	0.00	0.00	3.12	0.53	78.00
1	Clear work control responsibilities.	25	0.36	0.48	0.16	0.00	0.00	3.20	0.51	80.00
2	Effectiveness evaluation and review	25	0.32	0.52	0.16	0.00	0.00	3.16	0.50	79.00
3	Work reception staff training	25	0.20	0.44	0.24	0.48	0.00	3.08	0.42	77.00
4	Planning staff sufficiency	25	0.20	0.44	0.24	0.48	0.00	3.08	0.42	77.00
5	Establishing of data analysis for management use	25	0.28	0.28	0.32	0.48	0.00	3.08	0.50	77.00
D	**Shop Organization**	25	0.20	0.48	0.20	0.48	0.00	2.97	0.47	74.29
1	Availability of documented shop functions	25	0.20	0.44	0.16	0.48	0.08	2.92	1.71	73.00
2	Clear related crafts relationships	25	0.20	0.40	0.24	0.64	0.00	3.12	0.41	78.00
3	Effectiveness review and evaluation	24	0.13	0.33	0.42	0.54	0.00	2.88	0.41	71.88
E	**Shop Supervision & Planning Functions**	24	0.17	0.54	0.17	0.13	0.00	2.68	0.60	66.93
1	Multi-craft job coordination	25	0.20	0.56	0.08	0.16	0.00	2.80	0.57	70.00
2	Supervision coverage adequacy	24	0.21	0.50	0.17	0.13	0.00	2.79	0.58	69.79
3	Establishment of planning functions to support shop supervisors.	25	0.12	0.48	0.20	0.12	0.08	2.44	1.12	61.00
F	**First Line Supervision & Responsibilities**	24	0.29	0.50	0.13	0.08	0.00	2.93	0.59	73.33
1	Ratio of supervisors to craft workers	25	0.28	0.52	0.12	0.08	0.00	3.00	0.54	75.00
2	Availability of adequate support staff	25	0.24	0.40	0.28	0.08	0.00	2.80	0.61	70.00
3	Labor productivity follow-up	25	0.32	0.44	0.16	0.08	0.00	3.00	0.58	75.00

Factor No	Description	No. of Respondents	Extremely Important %	Important %	Moderately Important %	Little Important %	Not Important %	Mean	Standard Deviation	Importance Index
G	**Training**	25	0.44	0.28	0.16	0.12	0.00	2.86	0.77	71.61
1	Technical training	25	0.40	0.40	0.08	0.04	0.08	3.00	1.19	75.00
2	Productivity training	25	0.28	0.40	0.12	0.20	0.00	2.76	0.69	69.00
3	Management training	24	0.29	0.42	0.21	0.00	0.08	2.83	0.65	70.83
H	**Motivation**	25	0.36	0.40	0.08	0.16	0.00	2.72	0.81	67.93
1	Conducting a climate survey	24	0.21	0.50	0.04	0.25	0.00	2.67	0.67	66.67
2	Annual turnover due to quits and discharges of labors.	25	0.16	0.44	0.16	0.16	0.08	2.44	1.19	61.00
3	Employees financial motivation	25	0.40	0.28	0.12	0.12	0.08	2.80	1.32	70.00
4	Employees awards and recognition	25	0.40	0.36	0.08	0.12	0.04	2.96	1.17	74.00
5	Less barriers between labor and management	25	0.16	0.60	0.04	0.20	0.00	2.72	0.57	68.00
	Total								24.96	2710.79
	Average Score									73.26

Second Component - Workload Identification & Performance Measures (Government Sector)

Factor No	Question	No. of espondent	Extremely Important	Important	Moderately Important	Little Important	Not Importan	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
A	**Facility Condition Inspection**	25	0.28	0.52	0.20	0.00	0.00	3.01	0.53	75.33
1	Availability of inspection staff	25	0.28	0.56	0.08	0.08	0.00	3.04	0.52	76.00
2	Availability of documented inspection scheduling	25	0.16	0.60	0.24	0.08	0.00	3.00	0.41	75.00
3	Conducting maintenance & repairs based on inspection	25	0.20	0.60	0.20	0.00	0.00	3.00	0.46	75.00
B	**Work Request Procedure**	25	0.36	0.48	0.16	0.00	0.00	3.17	0.52	79.33
1	Availability of work order system	25	0.52	0.44	0.04	0.00	0.00	3.48	0.50	87.00
2	Availability of documented procedure	25	0.32	0.52	0.04	0.12	0.00	3.04	0.56	76.00
3	Information feedback to requester	25	0.32	0.48	0.12	0.04	0.04	3.00	0.82	75.00
C	**Relationship Between Sections**	25	0.44	0.28	0.24	0.04	0.00	3.00	0.68	75.00
1	Personnel understanding of their works relationships	25	0.48	0.24	0.20	0.08	0.00	3.12	0.63	78.00
2	Job description of each section	25	0.40	0.28	0.24	0.08	0.00	3.00	0.65	75.00
3	Team work assignment for the same jobs	25	0.36	0.24	0.32	0.08	0.00	2.88	0.69	72.00
D	**Preventive Maintenance (Equipment)**	24	0.21	0.58	0.21	0.00	0.00	2.95	0.49	73.64
1	Planned preventive maintenance	25	0.28	0.48	0.24	0.00	0.00	3.04	0.52	76.00
2	Accomplishing preventive maintenance work within 10% of schedule	24	0.17	0.58	0.25	0.00	0.00	2.92	0.46	72.92
3	Periodically reviewing equipment history records	25	0.20	0.52	0.24	0.04	0.00	2.88	0.52	72.00
E	**Service Work**	25	0.04	0.40	0.48	0.08	0.00	2.16	0.66	54.00
1	Classifying service works separately from other works	25	0.08	0.36	0.40	0.16	0.00	2.36	0.61	59.00
2	Clearly documenting processing procedure of service works	25	0.00	0.36	0.44	0.20	0.00	2.16	0.51	54.00
3	Conducting work load analysis	25	0.04	0.28	0.36	0.24	0.08	1.96	1.36	49.00
F	**Routine, Recurring Work**	25	0.04	0.36	0.48	0.12	0.00	2.27	0.57	56.67
1	Classifying recurring work to be controlled separately	25	0.04	0.32	0.40	0.24	0.00	2.16	0.61	54.00

Factor No	Question	No. of espondent	Extremely Important	Important	Moderately Important	Little Important	Not Importan	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
2	Reporting standing work order scheduling & performance weekly	25	0.04	0.36	0.48	0.12	0.00	2.32	0.54	58.00
3	Cost estimation of recurring work	25	0.08	0.44	0.28	0.12	0.08	2.32	1.46	58.00
G	**Work Requirements Documentation**	25	0.24	0.52	0.12	0.12	0.00	2.65	0.72	66.33
1	Establishing prioritization of all works	25	0.28	0.48	0.16	0.08	0.00	2.96	0.56	74.00
2	Summarizing works by status	25	0.20	0.36	0.32	0.12	0.00	2.64	0.66	66.00
3	Reviewing work load periodically	25	0.16	0.36	0.24	0.16	0.08	2.36	1.68	59.00
	Total								18.88	1921.22
	Average Score									68.62

Third Component - Work Planning & Scheduling (Government Sector)

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
A	**Priority System**	25	0.40	0.20	0.28	0.12	0.00	2.88	0.73	71.97
1	Documentation & distribution of priority criteria	25	0.40	0.20	0.28	0.12	0.00	2.88	0.73	72.00
2	Appropriateness of priority criteria	24	0.33	0.38	0.17	0.13	0.00	2.92	0.64	72.92
3	Consistency of priority criteria	25	0.36	0.28	0.20	0.16	0.00	2.84	0.72	71.00
B	**Work Classification and Weekly Schedule**	25	0.12	0.44	0.44	0.00	0.00	2.5	0.63	62.50
1	Work Classification for all tasks.	25	0.20	0.32	0.36	0.08	0.04	2.56	1.84	64.00
2	Developing and implementing work processing procedure.	25	0.08	0.52	0.20	0.16	0.04	2.44	0.88	61.00
3	Weekly scheduling for conducting works.	24	0.08	0.42	0.46	0.00	0.04	2.5	0.55	62.50
C	**Alterations and Improvement Work**	25	0.16	0.52	0.28	0.04	0.00	2.65	0.61	66.33
1	Classifying alterations and improvement separately from maintenance works.	25	0.16	0.52	0.20	0.08	0.00	2.68	0.59	67.00
2	Processing and programming of work separately from maintenance.	25	0.16	0.40	0.32	0.12	0.04	2.6	0.63	65.00
3	Distribution of work force within a planned target.	25	0.16	0.52	0.16	0.16	0.00	2.68	0.59	67.00
D	**Budget Requirements for Maintenance and Repairs**	25	0.32	0.48	0.16	0.00	0.04	2.96	0.60	74.00
1	Planning annual maintenance budget.	25	0.36	0.44	0.12	0.00	0.08	3	0.61	75.00
2	Cost reporting & budget documentation	25	0.32	0.44	0.16	0.00	0.08	2.92	0.63	73.00
3	Formally identifying and presenting long-range requir requriements for renewals and replacement to financial managers.	25	0.36	0.40	0.16	0.00	0.08	2.96	0.64	74.00
E	**Budget Execution Plan**	25	0.36	0.40	0.16	0.00	0.08	2.84	0.72	71.00
1	Establishing periodic budget execution planning	25	0.36	0.36	0.08	0.12	0.08	2.8	1.29	70.00
2	Identifying work in the budget plan.	25	0.44	0.24	0.24	0.00	0.08	2.96	0.70	74.00
3	Controlling budget against expenditure	25	0.28	0.40	0.20	0.04	0.08	2.76	1.16	69.00

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
F	**Backlog of Funded Works**	25	0.08	0.40	0.32	0.16	0.04	2.32	0.99	58.00
1	Defining accepted and applied backlog	25	0.12	0.40	0.28	0.16	0.04	2.4	1.04	60.00
2	Backlog summaries of approved works	25	0.08	0.32	0.40	0.16	0.04	2.24	0.97	56.00
3	Backlog reports review and analysis	25	0.16	0.28	0.32	0.20	0.04	2.32	1.11	58.00
G	**Emergency Works & Shutdown Scheduling**	25	0.28	0.60	0.08	0.04	0.00	2.81	0.66	70.25
1	Minimizing emergency work occurrence	25	0.36	0.44	0.16	0.04	0.00	3.12	0.54	78.00
2	Standard time assessment of specific works	25	0.28	0.40	0.28	0.04	0.00	2.92	0.59	73.00
3	Shutdown scheduling and planning	25	0.24	0.36	0.28	0.08	0.04	2.68	1.07	67.00
4	Long term plans	25	0.24	0.32	0.24	0.12	0.08	2.52	1.23	63.00
	Total								23.67	1966.47
	Average Score									67.81

Fourth Component - Work Accomplishment (Government Sector)

Factor No	Question	No. of Respondents	Extremely Important %	Important %	Moderately Important %	Little Important %	Not Important %	Mean	Standard Deviation	Importance Index
A	**Shop Scheduling & Planning Procedure**	25	0.16	0.40	0.44	0.00	0.00	2.61	0.62	65.25
1	Establishing weekly scheduling	25	0.24	0.36	0.36	0.04	0.00	2.80	0.61	70.00
2	Documenting & reviewing scheduling procedures weekly.	25	0.16	0.40	0.28	0.16	0.00	2.56	0.65	64.00
3	Performance within +10% of planned works.	25	0.20	0.36	0.36	0.08	0.00	2.68	0.90	67.00
4	Shop planning support availability	25	0.16	0.32	0.36	0.08	0.08	2.40	1.65	60.00
B	**Craft and Material Availability**	25	0.32	0.48	0.12	0.08	0.00	2.97	0.89	74.22
1	Craft distribution planning for shop workforce.	25	0.32	0.40	0.16	0.04	0.08	2.84	1.47	71.00
2	Work ordering Scheduling for craft hours	25	0.28	0.36	0.16	0.12	0.08	2.64	1.81	66.00
3	Material scheduling for individual work orders	25	0.32	0.40	0.20	0.08	0.00	2.96	0.60	74.00
4	Material and equipment availability	23	0.48	0.48	0.04	0.00	0.00	3.43	0.50	85.87
C	**Maintenance Process Re-Engineering**	25	0.16	0.56	0.16	0.04	0.08	2.74	1.34	68.45
1	Designing Key maintenance processes	25	0.20	0.52	0.16	0.12	0.00	2.80	0.57	70.00
2	Work process automation	25	0.20	0.44	0.24	0.04	0.08	2.64	1.44	66.00
3	Quality cost measuring	25	0.24	0.44	0.20	0.04	0.08	2.72	1.45	68.00
4	Establishing performance indicators.	24	0.25	0.50	0.13	0.04	0.08	2.79	1.35	69.79
D	**Shop, Spaces, Tools & Equipment**	25	0.32	0.36	0.24	0.00	0.08	2.80	0.70	70.00
1	Shop space adequacy	25	0.32	0.32	0.16	0.12	0.00	2.68	0.78	67.00
2	Tools and equipment adequacy	25	0.32	0.44	0.12	0.12	0.08	2.96	1.98	74.00
3	Maintained shop and facilities condition	25	0.20	0.52	0.20	0.00	0.00	2.76	0.59	69.00
E	**Transportation**	25	0.32	0.40	0.16	0.12	0.00	2.91	0.63	72.67
1	Adequate number of vehicles for maintenance transportation.	25 25	0.36 0.24	0.36 0.48	0.16 0.16	0.12 0.12	0.00 0.00	2.96 2.84	0.64 0.59	74.00 71.00
2	Adequate operation & maintenance of vehicles									
3	Tools availability	25	0.20	0.60	0.16	0.00	0.04	2.92	0.50	73.00
F	**Supervisory Practices**	25	0.36	0.40	0.16	0.08	0.00	2.92	0.66	72.96
1	Spending enough percentage of supervisor's time on direct supervision.	25	0.40	0.32	0.16	0.12	0.00	3.00	0.65	75.00

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
2	Clear supervisory responsibilities	25	0.32	0.52	0.04	0.12	0.00	3.04	0.56	76.00
3	Identifying training & safety programs by supervisors.	25	0.20	0.56	0.16	0.00	0.08	2.80	0.57	70.00
4	Labor and material cost estimation	24	0.29	0.42	0.21	0.00	0.08	2.83	0.65	70.83
G	**Use of Contracts**	25	0.36	0.48	0.04	0.12	0.00	2.90	0.68	72.50
1	Balancing contracts and in-house staff	25	0.24	0.40	0.24	0.00	0.12	2.64	0.72	66.00
2	Contract administration by experienced and trained personnel	25	0.40	0.40	0.12	0.00	0.08	3.04	0.62	76.00
3	Monitored contract performance	25	0.40	0.44	0.04	0.12	0.00	3.12	0.57	78.00
4	Frequent management evaluation and comparisons between contract & in-house performance.	25	0.32	0.36	0.20	0.04	0.08	2.80	1.19	70.00
	Total								29.13	2337.53
	Average Score									70.83

Fifth Component - Information Technology & Appraisal (Government Sector)

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
A	**Management Information System (MIS)**	25	0.24	0.52	0.12	0.12	0.00	2.73	0.67	68.20
1	Maintenance MIS adequacy	25	0.20	0.48	0.20	0.04	0.08	2.68	1.11	67.00
2	Report design and utilization	25	0.20	0.56	0.16	0.08	0.00	2.88	0.52	72.00
3	Facility and equipment reports	25	0.12	0.60	0.16	0.12	0.00	2.72	0.50	68.00
4	Easy to use maintenance management system	25	0.24	0.44	0.24	0.08	0.00	2.84	0.59	71.00
5	Using expert systems	25	0.20	0.32	0.36	0.04	0.08	2.52	1.12	63.00
B	**Measurement of Performance**	25	0.28	0.44	0.20	0.08	0.00	2.72	0.72	68.00
1	Using performance measurement methods	25	0.32	0.36	0.24	0.00	0.08	2.84	0.68	71.00
2	Report summaries preparation	25	0.32	0.28	0.28	0.12	0.00	2.8	0.70	70.00
3	Using engineered performance standards to estimate labor hours on work orders.	25	0.20	0.48	0.20	0.04	0.08	2.68	1.11	67.00
4	Conducting improvement studies.	25	0.20	0.44	0.20	0.04	0.08	2.56	1.11	64.00
C	**Productivity Measurement**	25	0.36	0.36	0.20	0.00	0.08	2.82	0.73	70.44
1	Frequent productivity studies	25	0.32	0.40	0.20	0.00	0.08	2.88	0.65	72.00
2	Conducting work sampling of representative shop workforce.	25	0.36	0.28	0.28	0.00	0.08	2.84	0.72	71.00
3	Comparisons of various categories of work	25	0.24	0.48	0.20	0.00	0.08	2.8	0.62	70.00
4	Conducting improvement action plan	24	0.25	0.46	0.17	0.04	0.08	2.75	1.15	68.75
D	**Information System & Historical Records**	25	0.20	0.60	0.16	0.04	0.00	2.87	0.53	71.75
1	Availability of facility history records	25	0.12	0.76	0.08	0.04	0.00	2.96	0.37	74.00
2	Availability of equipment history records	25	0.08	0.72	0.16	0.04	0.00	2.84	0.36	71.00
3	Spare parts information	25	0.20	0.60	0.12	0.08	0.00	2.92	0.50	73.00
4	Computerized inventory system	25	0.20	0.56	0.12	0.04	0.08	2.76	1.09	69.00
E	**Variance Review**	25	0.12	0.48	0.36	0.04	0.00	2.67	0.53	66.67
1	Review policy for variance between planned and actual activities.	25	0.12	0.52	0.36	0.00	0.00	2.76	0.47	69.00
2	Establishing parameters and guidelines for conducting these reviews.	25	0.12	0.48	0.40	0.00	0.00	2.72	0.49	68.00
3	Variance records and periodic review	25	0.12	0.32	0.52	0.04	0.00	2.52	0.59	63.00
	Total								17.62	1726.80
	Average Score									69.07

Sixth Component - Material Management (Government Sector)

Factor No	Question	No. of espondent	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
A	**Parts & Material Availability**	25	0.44	0.36	0.12	0.04	0.04	3.08	1.05	77.00
1	Periodic inventory review	25	0.28	0.36	0.24	0.04	0.08	2.72	1.17	68.00
2	Documentation of material used on work order sheet.	25	0.56	0.24	0.12	0.08	0.00	3.28	0.98	82.00
3	Spare parts availability	25	0.56	0.24	0.08	0.12	0.00	3.24	1.05	81.00
B	**Storeroom Operation**	25	0.36	0.44	0.16	0.04	0.00	2.92	0.86	73.00
1	Storeroom control procedure and record system	25	0.32	0.52	0.04	0.12	0.00	3.04	0.93	76.00
2	Security and accessibility	25	0.36	0.40	0.16	0.08	0.00	3.04	0.93	76.00
3	Stock Safety	25	0.44	0.32	0.16	0.00	0.08	3.04	1.17	76.00
4	Integration of salvage and "bench stock" with inventory control.	25	0.20	0.44	0.20	0.04	0.08	2.56	1.11	64.00
C	**Inventory Functions and Costs**	25	0.16	0.40	0.32	0.04	0.08	2.45	1.09	61.33
1	Purchase orders cost management	25	0.20	0.40	0.28	0.04	0.08	2.6	1.12	65.00
2	Materials handling cost management	25	0.16	0.28	0.44	0.04	0.08	2.4	1.08	60.00
3	Materials stock out cost management	25	0.16	0.32	0.32	0.12	0.08	2.36	1.15	59.00
	Total								13.70	918.33
	Average Score									70.64

First Component: Organization and Human Resources (Private Sector)

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
A	**Organization Structure**	22	0.64	0.36	0.00	0.00	0.00	3.41	0.54	85.29
1	Availability of organization chart	22	0.59	0.41	0.00	0.00	0.00	3.59	0.50	89.77
2	Availability of function statement for all components which define roles, authority and responsibility.	21	0.43	0.38	0.19	0.00	0.00	3.24	0.53	80.95
3	Job description for each position	22	0.59	0.36	0.05	0.00	0.00	3.55	0.49	88.64
4	Data updating procedure	22	0.45	0.36	0.18	0.00	0.00	3.27	0.53	81.82
B	**Policies, Rules and Services**	22	0.50	0.50	0.00	0.00	0.00	3.35	0.53	83.71
1	Availability of general policies and objectives documentation.	22	0.45	0.55	0.00	0.00	0.00	3.45	0.51	86.36
2	Complete services organization clearly defined	22	0.45	0.55	0.00	0.00	0.00	3.45	0.51	86.36
3	Availability of active updating procedure	22	0.36	0.50	0.09	0.00	0.00	3.14	0.54	78.41
C	**Work Control Center Functions, Staffing**	22	0.73	0.27	0.00	0.00	0.00	3.46	0.53	86.59
1	Clear work control responsibilities.	22	0.73	0.27	0.00	0.00	0.00	3.73	0.46	93.18
2	Effectiveness evaluation and review	22	0.36	0.59	0.05	0.00	0.00	3.32	0.49	82.95
3	Work reception staff training	22	0.45	0.55	0.00	0.00	0.00	3.45	0.51	86.36
4	Planning staff sufficiency	22	0.50	0.50	0.00	0.00	0.00	3.50	0.51	87.50
5	Establishing of data analysis for management use.	22	0.50	0.32	0.18	0.00	0.00	3.32	0.53	82.95
D	**Shop Organization**	22	0.41	0.36	0.23	0.00	0.00	3.15	0.56	78.79
1	Availability of documented shop functions	22	0.50	0.32	0.18	0.00	0.00	3.32	0.53	82.95
2	Clear related crafts relationships	22	0.41	0.41	0.18	0.00	0.00	3.23	0.53	80.68
3	Effectiveness review and evaluation	22	0.23	0.45	0.32	0.00	0.00	2.91	0.54	72.73
E	**Shop Supervision & Planning Functions**	22	0.23	0.64	0.14	0.00	0.00	3.02	0.48	75.38
1	Multi-craft job coordination	22	0.23	0.64	0.14	0.00	0.00	3.09	0.45	77.27
2	Supervision coverage adequacy	22	0.18	0.64	0.14	0.05	0.00	2.95	0.46	73.86
3	Establishment of planning functions to support shop supervisors.	22	0.18	0.68	0.09	0.05	0.00	3.00	0.44	75.00
F		22	0.41	0.55	0.05	0.00	0.00	3.29	0.51	82.20
1	**First Line Supervision & Responsibilities**	22	0.45	0.41	0.14	0.00	0.00	3.32	0.51	82.95
2	Ratio of supervisors to craft workers	22	0.32	0.59	0.09	0.00	0.00	3.23	0.48	80.68
3	Availability of adequate support staff	22	0.41	0.50	0.09	0.00	0.00	3.32	0.50	82.95
	Labor productivity follow-up									

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
G	**Training**	22	0.41	0.59	0.00	0.00	0.00	3.29	0.52	82.20
1	Technical training	22	0.64	0.36	0.00	0.00	0.00	3.64	0.49	90.91
2	Productivity training	22	0.41	0.55	0.05	0.00	0.00	3.36	0.50	84.09
3	Management training	22	0.23	0.55	0.14	0.05	0.00	2.86	0.56	71.59
H	**Motivation**	22	0.41	0.50	0.05	0.00	0.00	3.24	0.53	80.91
1	Conducting a climate survey	21	0.43	0.57	0.05	0.00	0.00	3.36	0.51	84.09
2	Annual turnover due to quits and discharges of laborers	22	0.32	0.55	0.18	0.00	0.00	3.27	0.47	81.82
3	Employees financial motivation	22	0.45	0.45	0.05	0.00	0.00	3.27	0.54	81.82
4	Employees awards and recognition	22	0.50	0.41	0.05	0.05	0.00	3.36	0.52	84.09
5	Less barriers between labor and management	22	0.23	0.55	0.14	0.09	0.00	2.91	0.54	72.73
	Total								18.88	3040.57
	Average Score									82.18

Second Component - Work Load Identification & Performance Measures (Private Sector)

Factor No	Question	No. of Respondents	Extremely Important %	Important %	Moderately Important %	Little Important %	Not Important %	Mean	Standard Deviation	Importance Index
A	**Facility Condition Inspection**	22	0.32	0.64	0.05	0.00	0.00	3.27	0.48	81.82
1	Availability of inspection staff	22	0.32	0.64	0.05	0.00	0.00	3.27	0.48	81.82
2	Availability of documented inspection scheduling	22	0.36	0.59	0.05	0.00	0.00	3.32	0.49	82.95
3	Conducting maintenance & repairs based on inspection	22	0.27	0.68	0.05	0.00	0.00	3.23	0.46	80.68
B	**Work Request Procedure**	22	0.64	0.36	0.00	0.00	0.00	3.59	0.49	89.77
1	Availability of work order system	22	0.82	0.18	0.00	0.00	0.00	3.82	0.39	95.45
2	Availability of documented procedure	22	0.55	0.45	0.00	0.00	0.00	3.55	0.51	88.64
3	Information feedback to requester	22	0.50	0.41	0.09	0.00	0.00	3.41	0.50	85.23
C	**Relationship Between Sections**	22	0.55	0.45	0.00	0.00	0.00	3.35	0.55	83.71
1	Personnel understanding of their work relationships.	22	0.45	0.50	0.05	0.00	0.00	3.41	0.50	85.23
2	Job description of each section	22	0.36	0.55	0.09	0.00	0.00	3.27	0.49	81.82
3	Team work assignment for the same jobs	22	0.36	0.64	0.00	0.00	0.00	3.36	0.49	84.09
D	**Preventive Maintenance (Equipment)**	22	0.50	0.41	0.09	0.00	0.00	3.26	0.56	81.44
1	Planned preventive maintenance	22	0.59	0.32	0.09	0.00	0.00	3.50	0.49	87.50
2	Accomplishing preventive maintenance work within 10% of schedule.	22	0.32	0.45	0.23	0.00	0.00	3.09	0.53	77.27
3	Periodically reviewing equipment history records.	22	0.41	0.36	0.23	0.00	0.00	3.18	0.55	79.55
E	**Service Work**	22	0.14	0.45	0.32	0.09	0.00	2.48	0.67	62.12
1	Classifying service work separately from other work	22	0.14	0.55	0.23	0.09	0.00	2.64	0.58	65.91
2	Clearly documenting processing procedure of service work	22	0.14	0.41	0.32	0.14	0.00	2.41	0.71	60.23
3	Conducting work load analysis.	22	0.09	0.50	0.27	0.14	0.00	2.41	0.65	60.23
F	**Routine, Recurring Work**	22	0.09	0.55	0.36	0.00	0.00	2.64	0.50	65.91
1	Classifying recurring work to be controlled separately	22	0.09	0.45	0.41	0.05	0.00	2.55	0.55	63.64

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Agreement Index
			%	%	%	%	%			
2	Reporting standing work order scheduling & performance weekly.	22	0.14	0.41	0.45	0.00	0.00	2.68	0.54	67.05
3	Cost estimation of recurring work	22	0.09	0.50	0.41	0.00	0.00	2.68	0.47	67.05
G	**Work Requirements Documentation**	22	0.41	0.59	0.00	0.00	0.00	3.20	0.55	79.92
1	Establishing prioritization of all works	22	0.41	0.59	0.00	0.00	0.00	3.41	0.50	85.23
2	Summarizing works by status	22	0.27	0.64	0.09	0.00	0.00	3.18	0.46	79.55
3	Reviewing work load periodically	22	0.27	0.45	0.27	0.00	0.00	3.00	0.53	75.00
	Total								14.69	2178.79
	Average Score									77.81

Third Component - Work Planning & Scheduling (Private Sector)

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
A	**Priority System**	22	0.55	0.41	0.05	0.00	0.00	2.86	0.86	71.59
1	Documentation & distribution of priority criteria	22	0.36	0.18	0.00	0.00	0.00	2.00	1.31	50.00
2	Appropriateness of priority criteria	22	0.36	0.59	0.05	0.00	0.00	3.32	0.49	82.95
3	Consistency of priority criteria	22	0.32	0.64	0.05	0.00	0.00	3.27	0.48	81.82
B	**Work Classification and Weekly Schedule**	22	0.23	0.64	0.14	0.00	0.00	3.06	0.46	76.52
1	Work Classification for all tasks.	22	0.27	0.50	0.23	0.00	0.00	3.05	0.51	76.14
2	Developing and implementing work processing procedure.	22	0.18	0.68	0.14	0.00	0.00	3.05	0.42	76.14
3	Weekly scheduling for conducting works.	22	0.23	0.64	0.14	0.00	0.00	3.09	0.45	77.27
C	**Alterations and Improvement Work**	22	0.32	0.45	0.23	0.00	0.00	3.08	0.54	76.89
1	Classifying alterations and improvement separately from maintenance works.	22	0.32	0.45	0.23	0.00	0.00	3.09	0.53	77.27
2	Processing and programming of work separately from maintenance.	22	0.23	0.55	0.23	0.00	0.00	3.00	0.49	75.00
3	Distribution of work force within a planned target.	22	0.32	0.50	0.18	0.00	0.00	3.14	0.51	78.41
D	**Budget Requirements for Maintenance and Repairs**	22	0.68	0.27	0.05	0.00	0.00	3.48	0.51	87.12
1	Planning annual maintenance budget.	22	0.68	0.27	0.05	0.00	0.00	3.64	0.46	90.91
2	Cost reporting & budget documentation	22	0.45	0.50	0.05	0.00	0.00	3.41	0.50	85.23
3	Formally identifying and presenting long-range req requriements for renewals and replacement to financial managers.	22	0.50	0.41	0.09	0.00	0.00	3.41	0.50	85.23
E	**Budget Execution Plan**	22	0.59	0.41	0.00	0.00	0.00	3.39	0.54	84.85
1	Establishing periodic budget execution planning	22	0.50	0.32	0.18	0.00	0.00	3.32	0.53	82.95
2	Identifying works in the budget plan.	22	0.45	0.50	0.05	0.00	0.00	3.41	0.50	85.23
3	Controlling budget against expenditure	22	0.45	0.55	0.00	0.00	0.00	3.45	0.51	86.36

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
F	**Backlog of Funded Works**	22	0.27	0.64	0.09	0.00	0.00	3.20	0.46	79.92
1	Defining accepted and applied backlog	22	0.36	0.55	0.09	0.00	0.00	3.27	0.49	81.82
2	Backlog summaries of approved works	22	0.23	0.68	0.09	0.00	0.00	3.14	0.44	78.41
3	Backlog reports review and analysis	22	0.27	0.64	0.09	0.00	0.00	3.18	0.46	79.55
G	**Emergency Works & Shutdown Scheduling**	22	0.64	0.36	0.00	0.00	0.00	3.45	0.53	86.36
1	Minimizing emergency work occurrence	22	0.73	0.27	0.00	0.00	0.00	3.73	0.46	93.18
2	Standard time assessment of specific works	22	0.41	0.50	0.09	0.00	0.00	3.32	0.50	82.95
3	Shutdown scheduling and planning	22	0.73	0.18	0.09	0.00	0.00	3.64	0.42	90.91
4	Long term plans	22	0.36	0.50	0.09	0.05	0.00	3.14	0.54	78.41
	Total								15.39	2339.39
	Average Score									80.67

Fourth Component - Work Accomplishment (Private Sector)

Factor No	Question	No. of Respondents	Extremely Important %	Important %	Moderately Important %	Little Important %	Not Important %	Mean	Standard Deviation	Importance Index
A	**Shop Scheduling & Planning Procedure**	22	0.27	0.59	0.14	0.00	0.00	3.02	0.52	75.57
1	Establishing weekly scheduling	22	0.45	0.41	0.14	0.00	0.00	3.32	0.51	82.95
2	Documenting & reviewing scheduling procedures weekly.	22	0.27	0.59	0.14	0.00	0.00	3.14	0.47	78.41
3	Performance within +10% of planned works.	22	0.18	0.55	0.27	0.00	0.00	2.91	0.48	72.73
4	Shop planning support availability	22	0.05	0.64	0.32	0.00	0.00	2.73	0.36	68.18
B	**Craft and Material Availability**	22	0.41	0.59	0.00	0.00	0.00	3.24	0.53	80.97
1	Craft distribution planning for shop workforce.	22	0.36	0.64	0.00	0.00	0.00	3.36	0.49	84.09
2	Work ordering Scheduling for craft hours	22	0.32	0.64	0.05	0.00	0.00	3.27	0.48	81.82
3	Material scheduling for individual work orders	22	0.14	0.77	0.09	0.00	0.00	3.05	0.36	76.14
4	Material and equipment availability	22	0.27	0.73	0.00	0.00	0.00	3.27	0.46	81.82
C	**Maintenance Process Re-Engineering**	22	0.18	0.59	0.23	0.00	0.00	2.91	0.48	72.73
1	Designing Key maintenance processes	22	0.23	0.55	0.23	0.00	0.00	3.00	0.49	75.00
2	Work process automation	22	0.18	0.59	0.23	0.00	0.00	2.95	0.46	73.86
3	Quality cost measuring	22	0.18	0.59	0.23	0.00	0.00	2.95	0.46	73.86
4	Establishing performance indicators.	22	0.18	0.45	0.32	0.00	0.00	2.73	0.59	68.18
D	**Shop, Spaces, Tools & Equipment**	22	0.41	0.45	0.14	0.00	0.00	3.05	0.63	76.14
1	Shop space adequacy	22	0.41	0.41	0.18	0.00	0.00	3.23	0.53	80.68
2	Tools and equipment adequacy	22	0.41	0.32	0.23	0.00	0.00	3.05	0.63	76.14
3	Maintained shop and facilities condition	22	0.14	0.59	0.27	0.00	0.00	2.86	0.44	71.59
E	**Transportation**	22	0.32	0.50	0.09	0.09	0.00	2.91	0.63	72.73
1	Adequate number of vehicles for maintenance transportation.	22	0.32	0.50	0.09	0.09	0.00	3.05	0.55	76.14
2	Adequate operation & maintenance of vehicles	22	0.09	0.64	0.14	0.14	0.00	2.68	0.48	67.05
3	Tools availability	22	0.36	0.36	0.18	0.09	0.00	3.00	0.62	75.00
F	**Supervisory Practices**	22	0.59	0.36	0.05	0.00	0.00	3.41	0.53	85.23
1	Spending enough percentage of supervisor's time on direct supervision.	22	0.64	0.32	0.05	0.00	0.00	3.59	0.48	89.77
2	Clear supervisory responsibilities	22	0.41	0.59	0.00	0.00	0.00	3.41	0.50	85.23

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
3	Identifying training & safety programs by supervisors.	22	0.45	0.55	0.00	0.00	0.00	3.45	0.51	86.36
4	Labor and material cost estimation	22	0.23	0.73	0.05	0.00	0.00	3.18	0.43	79.55
G	**Use of Contracts**	22	0.18	0.73	0.09	0.00	0.00	3.18	0.39	79.55
1	Balancing contracts and in-house staff	22	0.32	0.45	0.18	0.00	0.05	3.00	0.58	75.00
2	Contract administration by experienced and trained personnel.	22	0.18	0.64	0.27	0.00	0.00	3.18	0.39	79.55
3	Monitored contract performance	22	0.36	0.50	0.14	0.00	0.00	3.23	0.50	80.68
4	Frequent management evaluation and comparison comparisons between contract & in-house performance.	22	0.41	0.50	0.09	0.00	0.00	3.32	0.50	82.95
	Total								16.46	2565.63
	Average Score									77.75

Fifth Component - Information Technology & Appraisal (Private Sector)

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
A	**Management Information System (MIS)**	22	0.32	0.64	0.05	0.00	0.00	3.18	0.50	79.55
1	Maintenance MIS adequacy	22	0.36	0.55	0.09	0.00	0.00	3.27	0.49	81.82
2	Report design and utilization	22	0.23	0.73	0.05	0.00	0.00	3.18	0.43	79.55
3	Facility and equipment reports	22	0.27	0.64	0.09	0.00	0.00	3.18	0.46	79.55
4	Easy to use maintenance management system	22	0.36	0.59	0.05	0.00	0.00	3.32	0.49	82.95
5	Using expert systems	22	0.05	0.86	0.09	0.00	0.00	2.95	0.23	73.86
B	**Measurement of Performance**	22	0.41	0.55	0.05	0.00	0.00	3.22	0.54	80.40
1	Using performance measurement methods	22	0.32	0.64	0.05	0.00	0.00	3.27	0.48	81.82
2	Report summaries preparation	22	0.27	0.68	0.05	0.00	0.00	3.23	0.46	80.68
3	Using engineered performance standards to estimate labor hours on work orders	22	0.23	0.68	0.09	0.00	0.00	3.14	0.44	78.41
4	Conducting improvement studies	22	0.32	0.59	0.09	0.00	0.00	3.23	0.48	80.68
C	**Productivity Measurement**	22	0.32	0.59	0.09	0.00	0.00	3.15	0.50	78.79
1	Frequent productivity studies	22	0.45	0.41	0.14	0.00	0.00	3.32	0.51	82.95
2	Conducting work sampling of representative shop workforce.	22	0.14	0.73	0.09	0.05	0.00	2.95	0.40	73.86
3	Comparisons of various categories of work	22	0.27	0.64	0.09	0.00	0.00	3.18	0.46	79.55
D	**Information System & Historical Records**	22	0.50	0.50	0.00	0.00	0.00	3.33	0.54	83.24
1	Availability of facility history records	22	0.41	0.50	0.09	0.00	0.00	3.32	0.50	82.95
2	Availability of equipment history records	22	0.32	0.68	0.00	0.00	0.00	3.32	0.48	82.95
3	Spare parts information	22	0.50	0.45	0.05	0.00	0.00	3.45	0.50	86.36
4	Computerized inventory system	22	0.36	0.50	0.14	0.00	0.00	3.23	0.50	80.68
E	**Variance Review**	22	0.05	0.73	0.23	0.00	0.00	2.80	0.31	70.08
1	Review policy for variance between planned and actual activities.	22	0.09	0.73	0.18	0.00	0.00	2.91	0.35	72.73
2	Establishing parameters and guidelines for conducting these reviews.	22	0.05	0.64	0.27	0.05	0.00	2.68	0.39	67.05
3	Variance records and periodic review	22	0.09	0.64	0.27	0.00	0.00	2.82	0.39	70.45
	Total								10.84	1890.91
	Average Score									78.79

Sixth Component - Material Management (Private Sector)

Factor No	Question	No. of Respondents	Extremely Important	Important	Moderately Important	Little Important	Not Important	Mean	Standard Deviation	Importance Index
			%	%	%	%	%			
A	**Parts & Material Availability**	22	0.64	0.23	0.14	0.00	0.00	3.48	0.48	87.12
1	Periodic inventory review	22	0.55	0.32	0.14	0.00	0.00	3.41	0.51	85.23
2	Documentation of material used on work order sheet.	22	0.55	0.32	0.14	0.00	0.00	3.41	0.51	85.23
3	Spare parts availability	22	0.64	0.36	0.00	0.00	0.00	3.64	0.49	90.91
B	**Storeroom Operation**	22	0.50	0.50	0.00	0.00	0.00	3.23	0.58	80.68
1	Storeroom control procedure and record system	22	0.55	0.45	0.00	0.00	0.00	3.55	0.51	88.64
2	Security and accessibility	22	0.59	0.41	0.00	0.00	0.00	3.59	0.50	89.77
3	Stock Safety	22	0.41	0.59	0.00	0.00	0.00	3.41	0.50	85.23
4	Integration of salvage and "bench stock" with inventory control.	22	0.14	0.27	0.45	0.09	0.00	2.36	0.71	59.09
C	**Inventory Functions and Costs**	22	0.18	0.50	0.32	0.00	0.00	2.68	0.62	67.05
1	Purchase orders cost management	22	0.18	0.64	0.18	0.00	0.00	3.00	0.44	75.00
2	Materials handling cost management	22	0.18	0.27	0.45	0.09	0.00	2.55	0.68	63.64
3	Materials stock out cost management	22	0.14	0.32	0.45	0.09	0.00	2.50	0.64	62.50
	Total								7.16	1020.08
	Average Score									78.47

APPENDIX B

Questionnaire

بسم الله الرحمن الرحيم

Ministry of Higher Education
King Fahd University of Petroleum & Minerals
College of Environmental Design
Architectural Engineering Program

وزارة التعليم العالي
جامعة الملك فهد للبترول والمعادن
كلية تصاميم البيئة
برنامج الهندسة المعمارية

Questionnaires

To Whom It May Concern

The department of Architectural Engineering of the College of the Environmental Design at King Fahd University of Petroleum & Minerals is making a study on factors affecting building maintenance management auditing in Saudi Arabia.

The main purpose of this study is to identify these factors and rank them according to their importance. We are kindly asking you to participate by answering the attached questionnaires. The information you give will be strictly confidential and used for academic reason only. Your participation is important in contributing to completion of this study. Questionnaires are comprising of two parts. The first part seeks information about your firm. The second part seeks information on the factors affecting building maintenance management auditing by ranking them. Your immediate action will be highly appreciated, and please forward your answers to the following address:

Abdulaziz M. Al-Zahrani
King Fahd University of Petroleum & Minerals
P.O. Box 5019
Dhahran 31261

Thank you in anticipation of your cooperation.

Sincerely yours,

Abdul-Mohsen Jan. 5, 2000

Dr. Abdul Mohsen Bin Abdullah Al-Hammad
Professor
Architectural Engineering Department
King Fahd University of Petroleum & Minerals

QUESTIONNAIRE

This questionnaire is part of the study on the "***Assessment of Factors Affecting Building Maintenance Management Auditing in Saudi Arabia***". Part I of questionnaire contains questions seeking organization information.

Part I: General Information

1. Organization name (optional)_____

2. Department name (optional)_____

3. Respondent name (optional)_____

4. What is the position of the respondent in the organization?

☐ Auditor ☐ Engineer/Architect ☐ Manager

☐ Supervisor ☐ Other (please specify)_____

5. How many years of experience in maintenance management have you had?

☐ 1 – 5 years ☐ 6 – 10 years ☐ 11 – 15 years

☐ More than 15 years

6. What is the nature of your organization?

☐ Private ☐ Governmental

7. What is the main function of your organization?

☐ Commercial

☐ Industrial

☐ Health Care

☐ Educational

☐ Other (please specify)_____

8. What is the number of employees in your organization?

☐ 1 – 100 ☐ 101 – 200 ☐ 201 – 300

☐ 301 – 400 ☐ 401 – to 500 ☐ More than 500

9. What is the number of employees in the Maintenance Department of your organization?

☐ 1 – 10 ☐ 11 – 20 ☐ 21 – 30

☐ 31 – 40 ☐ 41 – 50 ☐ More than 50

10. Are your operation and maintenance works partially or completely contracted?

☐ Yes ☐ No

11. If the answer to the previous question is yes, what operation and maintenance activities are contracted?

☐ All ☐ Elect/Mech. ☐ Major plants

☐ Horticulture ☐ Cleaning ☐ Specialized Eqt.

☐ Other (please specify)_____

12. Is maintenance management in your organization audited?

☐ Yes ☐ No

If the answer to question 12 above is yes, please answer questions 13 and 14.

13. How frequently is your maintenance management audited?

☐ Once a year ☐ Twice a year ☐ More than twice a year

☐ Other (please specify)_____

14. Who normally performs the audit?

☐ Internal Auditors ☐ External Auditors ☐ Consultants

☐ Others (Please specify)_____

Part II: Technical Information

Please select the most appropriate answer for each question according to its importance as per your experience in the maintenance department of your organization. Also, please note that blank blocks are left after each question for any additions.

First Component: Organization & Human Resources

No.	Questions	Extremely Important	Important	Moderately Important	Little Important	Not Important
A.	**Organization Structure**					
1.	Availability of organization chart					
2.	Availability of function statements for all components which define roles, authority & responsibility					
3.	Job description for each position					
4.	Data updating procedure					
5.						
6.						
B.	**Policies, Rules and Services**					
1.	Availability of general policies and objectives documentation					
2.	Complete services organization clearly defined					
3.	Availability of active updating procedure					
4.						
5.						
C.	**Work Control Center Functions, Staffing**					
1.	Clear work control responsibilities.					
2.	Effectiveness evaluation and review					
3.	Work reception staff training					
4.	Planning staff sufficiency					
5.	Establishing of data analysis for management use					
6.						
7.						
D.	**Shop Organization**					
1.	Availability of documented shop functions					
2.	Clear related crafts relationships					
3.	Effectiveness review and evaluation					
4.						
5.						

No.	Questions	Extremely Important	Important	Moderately Important	Little Important	Not Important
E.	**Shop Supervision & Planning Functions**					
1.	Multi-craft job coordination					
2.	Supervision coverage adequacy					
3.	Establishment of planning functions to support shop supervisors					
4.						
5.						
F.	**First Line Supervision & Responsibilities**					
1.	Ratio of supervisors to craft workers					
2.	Availability of adequate support staff					
3.	Labor productivity follow-up					
4.						
5.						
G.	**Training**					
1.	Technical training					
2.	Productivity training					
3.	Management training					
4.						
5.						
H.	**Motivation**					
1.	Conducting a climate survey					
2.	Annual turnover due to quits and discharges of laborers					
3.	Employees' financial motivation					
4.	Employees' awards and recognition					
5.	Less barriers between labor and management					
6.						
7.						

Second Component: Work Load Identification & Performance Measures

No.		Extremely Important	Important	Moderately Important	Little Important	Not Important
A.	**Facility Condition Inspection**					
1.	Availability of inspection staff					
2.	Availability of documented inspection scheduling					
3.	Conducting maintenance & repairs based on inspection					
4.						
5.						
B.	**Work Request Procedure**					
1.	Availability of work order system					
2.	Availability of documented procedure					
3.	Information feedback to requester					
4.						
5.						

No.		Extremely Important	Important	Moderately Important	Little Important	Not Important
C.	**Relationship Between Sections**					
1.	Personnel understanding of their work relationships					
2.	Job description of each section					
3.	Team work assignment for the same jobs					
4.						
5.						
D.	**Preventive Maintenance (Equipment)**					
1.	Planned preventive maintenance					
2.	Accomplishing preventive maintenance work within 10% of schedule					
3.	Periodically reviewing equipment history records.					
4.						
5.						
E.	**Service Work**					
1.	Classifying service works separately from other work					
2.	Clearly documenting processing procedure of service work					
3.	Conducting work load analysis					
4.						
5.						
F.	**Routine, Recurring Work**					
1.	Classifying recurring work to be controlled separately					
2.	Reporting standing work order scheduling & performance weekly					
3.	Cost estimation of recurring work					
4.						
5.						
G.	**Work Requirements Documentation**					
1.	Establishing prioritization of all work					
2.	Summarizing works by status					
3.	Reviewing work load periodically					
4.						
5.						

Third Component: Work Planning & Scheduling

No.	Questions	Extremely Important	Important	Moderately Important	Little Important	Not Important
A.	**Priority System**					
1.	Documentation & distribution of priority criteria					
2.	Appropriateness of priority criteria					

No.	Questions	Extremely Important	Important	Moderately Important	Little Important	Not Important
3.	Consistency of priority criteria					
4.						
5.						
B.	**Work Classification and Weekly Schedule**					
1.	Work Classification for all tasks					
2.	Developing and implementing work processing procedure					
3.	Weekly scheduling for conducting work					
4.						
5.						
C.	**Alterations and Improvement Work**					
1.	Classifying alterations and improvement separately from maintenance work					
2.	Processing and programming of work separately from maintenance					
3.	Distribution of work force within a planned target					
4.						
5.						
D.	**Budget Requirements for Maintenance and Repairs**					
1.	Planning annual maintenance budget					
2.	Cost reporting & budget documentation					
3.	Formally identifying and presenting long-range requirements for renewals and replacement to financial managers.					
4.						
5.						
E.	**Budget Execution Plan**					
1.	Establishing periodic budget execution planning					
2.	Identifying works in the budget plan.					
3.	Controlling budget against expenditure					
4.						
5.						
F.	**Backlog of Funded Work**					
1.	Defining accepted and applied backlog					
2.	Backlog summaries of approved work					
3.	Backlog reports review and analysis					
4.						
5.						
G.	**Emergency Work & Shutdown Scheduling**					
1.	Minimizing emergency work occurrence					
2.	Standard time assessment for specific jobs					

No.	Questions	Extremely Important	Important	Moderately Important	Little Important	Not Important
3.	Shutdown scheduling and planning					
4.	Long term plans					
5.						
6.						

Fourth Component: Work Accomplishment

No.	Questions	Extremely Important	Important	Moderately Important	Little Important	Not Important
A.	**Shop Scheduling & Planning Procedure**					
1.	Establishing weekly scheduling					
2.	Documenting & reviewing scheduling procedures weekly					
3.	Performance within ±10% of planned works					
4.	Shop planning support availability					
5.						
6.						
B.	**Craft and Material Availability**					
1.	Craft distribution planning for shop workforce					
2.	Work ordering scheduling for craft hours					
3.	Material scheduling for individual work orders					
4.	Material and equipment availability					
5.						
6.						
C.	**Maintenance Process Re-Engineering**					
1.	Designing Key maintenance processes					
2.	Work process automation					
3.	Quality cost measuring					
4.	Establishing performance indicators					
5.						
6.						
D.	**Shop, Spaces, Tools & Equipment**					
1.	Shop space adequacy					
2.	Tools and equipment adequacy					
3.	Maintenance of condition in shop & facilities					
4.						
5.						
E.	**Transportation**					
1.	Adequate number of vehicles for maintenance transportation					
2.	Adequate operation & maintenance of vehicles					
3.	Tools availability					
4.						
5.						
F.	**Supervisory Practices**					
1.	Spending high enough percentage of supervisor's time on direct supervision					

No.	Questions	Extremely Important	Important	Moderately Important	Little Important	Not Important
2.	Clear supervisory responsibilities					
3.	Identifying training & safety programs by supervisors					
4.	Labor and material cost estimation					
5.						
6.						
G.	**Use of Contracts**					
1.	Balancing contracts and in-house staff					
2.	Contract administration by experienced and trained personnel					
3.	Monitored contract performance					
4.	Frequent management evaluation and comparisons between contract and in-house performance					
5.						
6.						

Fifth Component: Information Technology & Appraisal

No.	Questions	Extremely Important	Important	Moderately Important	Little Important	Not Important
A.	**Management Information Systems (MIS)**					
1.	Maintenance of MIS adequacy					
2.	Report design and utilization					
3.	Facility and equipment reports					
4.	Easy to use maintenance management system					
5.	Using expert systems					
6.						
7.						
B.	**Measurement of Performance**					
1.	Using performance measurement methods					
2.	Report summaries preparation					
3.	Using engineered performance standards to estimate labor hours on work orders					
4.	Conducting improvement studies					
5.						
6.						
C.	**Productivity Measurement**					
1.	Frequent productivity studies					
2.	Conducting work sampling of representative shop workforce					
3.	Comparisons of various categories of work					
4.	Conducting improvement action plan					
5.						
6.						

No.	Questions	Extremely Important	Important	Moderately Important	Little Important	Not Important
D.	**Information System & Historical Records**					
1.	Availability of facility history records					
2.	Availability of equipment history records					
3.	Spare parts information					
4.	Computerized inventory system					
5.						
6.						
E.	**Variance Review**					
1.	Review policy for variance between planned and actual activities.					
2.	Establishing parameters and guidelines for conducting these reviews					
3.	Variance records and periodic review					
4.						
5.						

Sixth Component: Material Management

No.		Extremely Important	Important	Moderately Important	Little Important	Not Important
A.	**Parts & Material Availability**					
1.	Periodic inventory review					
2.	Documentation of material used on work order sheet					
3.	Spare parts availability					
4.						
5.						
B.	**Storeroom Operation**					
1.	Storeroom control procedure and record system					
2.	Security and accessibility					
3.	Stock Safety					
4.	Integration of salvage and "bench stock" with inventory control					
5.						
6.						
C.	**Inventory Functions and Costs**					
1.	Purchase orders cost management					
2.	Materials handling cost management					
3.	Materials stock out cost management					
4.						
5.						

Thank you for your participation in our study and for your valuable comments.